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Comprehensive
reclamation of
abandoned hard rock
mine sites in the
urban area of Butte

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COMPREHENSIVE RECLAMATION OF ABANDONED HARD ROCK MINE SITES IN THE URBAN AREA OF BUTTE AND WALKERVILLE, MONTANA

DEPARTMENT OF STATE LANDS



Hydrometrics



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COMPREHENSIVE RECLAMATION OF ABANDONED HARD ROCK MINE SITES
IN THE URBAN AREA OF BUTTE AND WALKERVILLE, MONTANA

- PHASE I -

For:

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CONTENTS

	Page
LIST OF FIGURES.....	iv
LIST OF TABLES.....	iv
LIST OF APPENDICES.....	vi
LIST OF EXHIBITS.....	vi
SUMMARY AND CONCLUSIONS.....	1
INTRODUCTION.....	4
SITE DESCRIPTION.....	7
IDENTIFICATION OF HAZARDS.....	10
PUBLIC SAFETY HAZARDS.....	11
PUBLIC HEALTH HAZARDS.....	18
WATER RESOURCES.....	29
GROVE GULCH.....	30
Surface Water.....	30
Groundwater.....	32
STORM SEWER SYSTEMS.....	33
Warren Avenue.....	33
Anaconda Road - Butte Brewery.....	34
Buffalo Gulch.....	34
Missoula Gulch.....	36
West Side Storm Drains.....	38
SOCIOECONOMIC ASSESSMENT.....	39
SOILS.....	41
SOIL CHARACTERISTICS.....	41
CONTAMINATION HAZARD.....	45



	Page
RECLAMATION CONSIDERATIONS.....	47
VEGETATION.....	51
SITE RANKING MATRIX.....	60
OVERVIEW OF APPLICABLE RECLAMATION TECHNOLOGY.....	67
STRUCTURAL MEASURES.....	68
NON-STRUCTURAL MEASURES.....	73
Rock Mulch.....	75
Revegetation.....	76
Removal of Waste Dumps and the Clark Tailings.....	77
Revegetate with Metal-Tolerant Plants.....	78
Conventional Revegetation.....	79
RECLAMATION OPTIONS.....	82
SAFETY HAZARD.....	82
Backfilling.....	94
Concrete Cap or Steel Grate.....	95
Concrete and Steel Cone.....	96
HEALTH HAZARD.....	97
Revegetation.....	97
Interception of Runoff.....	98
Rock Mulch.....	98
REFERENCES.....	100



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LIST OF FIGURES

	Page
FIGURE 1. BUTTE-WALKERVILLE STUDY AREA.....	8
FIGURE 2. MAJOR MINE SUBSIDENCE AREAS IN BUTTE.....	17
FIGURE 3. ENVIRONMENTAL PARAMETER MATRIX.....	61
FIGURE 4. DETAIL FOR BACKFILLING MINE SHAFTS.....	69
FIGURE 5. DETAIL FOR BACKFILLING MINE ADITS.....	70
FIGURE 6. TYPICAL CONE INSTALLATION.....	72
FIGURE 7. CONCEPTUAL DRAWING OF SHAFT CAPPING USING LARGE CONCRETE SLAB.....	74

LIST OF TABLES

		Page
TABLE 1.	ABANDONED MINES RECOMMENDED FOR RECLAMATION.....	14
TABLE 2.	DESCRIPTION OF SURFACE DUST SAMPLING PROGRAM.....	19
TABLE 3.	CHEMICAL ANALYSIS OF DUST SAMPLES FROM CLARK TAILINGS AREA, STREET SWEEPINGS AND PLAYGROUNDS....	20
TABLE 4.	PLAYGROUND AREAS NEAR MINE WASTE DUMPS.....	27
TABLE 5.	FEDERAL DRINKING WATER STANDARDS FOR PUBLIC WATER SUPPLIES.....	31
TABLE 6.	SOIL PHYSICAL CHARACTERISTICS OF WASTE DUMP MATERIALS.....	43
TABLE 7.	SOIL CHEMICAL CHARACTERISTICS OF WASTE DUMP MATERIALS.....	44
TABLE 8.	PLANT SPECIES OCCURRING ON OR ADJACENT TO ABANDONED MINES IN THE BUTTE AREA.....	52
TABLE 9.	VEGETATIVE COVER, ADJACENT LAND USE AND DOMINANT PLANT SPECIES ON ABANDONED MINES IN THE BUTTE AREA.....	58
TABLE 10.	ABANDONED MINE RATINGS BASED ON ENVIRONMENTAL PARAMETER MATRIX.....	63
TABLE 11.	RECLAMATION ALTERNATIVES FOR BUTTE AREA INACTIVE MINES AND RELATED FACILITIES.....	83
TABLE 12.	RECLAMATION ALTERNATIVES FOR BUTTE AREA WASTE DUMPS, PLAYGROUNDS AND THE CLARK TAILINGS.....	87
TABLE 13.	COST SUMMARY OF RECLAMATION OPTIONS.....	88
TABLE 14.	SHAFTS REQUIRING ADDITIONAL TESTING BEFORE FURTHER RECLAMATION.....	93

LIST OF APPENDICES

- APPENDIX A. DETAILED REPORT ON PUBLIC SAFETY HAZARDS
- APPENDIX B. SUBSIDENCE REPORT
- APPENDIX C. DETAILED ASSESSMENT OF AIR QUALITY IMPACTS
- APPENDIX D. WATER QUALITY DATA FOR STORM WATER RUNOFF
- APPENDIX E. SOCIOECONOMIC STUDY
- APPENDIX F. SOILS REPORT
- APPENDIX G. CONVENTIONAL REVEGETATION TECHNIQUES
- APPENDIX H. DETAILED COST COMPUTATIONS

LIST OF EXHIBITS

- EXHIBIT 1. LOCATION AND INDEX MAP
- EXHIBIT 2. WALKERVILLE AREA
- EXHIBIT 3. BUTTE AREA
- EXHIBIT 4. ARDSLEY BUTTE-TRAVONA AREA
- EXHIBIT 5. CLARK TAILINGS
- EXHIBIT 6. BUTTE-SILVER BOW STORM SEWERS NORTH OF I-15/I-90

SUMMARY AND CONCLUSIONS

The Butte-Walkerville urban area has been extensively disturbed by over 120 years of mining activity. As a result, the area has a large number of abandoned mines and related facilities, including shafts, open pits and a tailings disposal area. Many of these facilities are not adequately protected and constitute either an existing or potential threat to public health or safety. Purpose of this report was to identify abandoned mine lands in the Butte-Walkerville area where clear threats to public health or safety exist. These sites are eligible for reclamation under Public Law 95-87 SMCRA.

The Anaconda Minerals company has extensive mining, mineral processing and tailings disposal areas east and south of the urban area. Mining activity in these areas is covered by active permits and reclamation plans and is not part of this assessment. Also excluded were the extensive abandoned mine sites peripheral to the urban study area. The Colorado Tailings have been declared a Resource Conservation and Recovery Act (RCRA) site and were also excluded from this study. A total of 73 mine sites, including associated structures and waste dumps were examined in the Butte-Walkerville urban area. The Clark (Timber Butte) Tailings is the only tailings disposal site included in the study. Forty-two shafts of various depths and sizes were identified as either existing or potential public safety hazards.

Erosion occurs at many mine waste dump sites. Erosion from nine waste dumps is particularly severe and may constitute a health hazard. The eroded waste is carried onto adjacent streets where it is pulverized by local traffic making it subject to entrainment in the ambient air. Eroded waste dump material has also been carried by runoff onto three baseball fields where the material may be respired and ingested by players. The Clark Tailings are fine-grained and subject to entrainment in the ambient air by strong winds. Constituents in the eroded waste dump materials and tailings have been identified as those which can adversely affect public health.

An extensive literature review was made and numerous individuals were contacted concerning the technology of filling and sealing shafts and the reclamation of disturbed areas. Based on this review and extensive site surveys, reclamation options were examined and recommendations were developed. It is recommended that shafts less than 1000 feet deep be backfilled and deeper shafts be covered with reinforced concrete caps. Erosion of waste dumps can be controlled by construction of runoff interception channels along embankment tops. Waste dump materials deposited on baseball fields should be covered with soil and wind erosion of the Clark Tailings can be controlled by applying a rock mulch to the surface. Backfilling or partial backfilling of open pits would be very costly and repair of existing fences is recommended.

Approximate costs of reclamation options were developed for each site identified as a present or potential health or safety hazard. The

estimated cost to implement recommended reclamation of all identified sites is about two-million dollars.

INTRODUCTION

In June 1983, the Abandoned Mine Reclamation Bureau of the Montana Department of State Lands (DSL) contracted with Hydrometrics to conduct a two-phase study to identify hazardous abandoned mine sites in the Butte-Walkerville area and to develop control or abatement measures for these sites. This report describes the Phase I portion of the project and identifies all hazardous sites meeting eligibility requirements as defined in Public Law 95-87 (SMCRA), Title IV, 1977 and the recently published definition of the interpretation of Section 409(c) of that law. This report also describes reclamation alternatives for the identified sites. Study area boundaries (Exhibit I) were modified during the study to reflect the input of new information obtained from local residents, Butte-Silver Bow local government representatives, Montana Bureau of Mines and Geology staff, the Technical Advisory Committee and the detailed field studies. Phase II of the project will consist of preparation of detailed engineering plans and specifications for correction of identified hazards at sites selected by DSL for reclamation.

The Butte-Walkerville metropolitan area has been the site of extensive mining and milling operations from the early 1860's through June 1983 when the Anaconda Minerals Company suspended mining and milling operations at its Butte facilities. As a result of this historic mining and related activity hundreds of shafts were sunk and extensive waste rock dumps were created in or near residential and business

areas. All of this activity predated by many years implementation of Montana's Hard Rock Mining Act.

Identification of open or hazardous mine shafts was clearly of major importance in the Butte area. Few, if any, areas in the United States have the concentration of mine shafts and openings as are present in Butte. A concentrated effort was made to examine all mines in the metropolitan area. However, early day mining records are not complete and some records may not be totally accurate. Therefore, it is probable that some small shafts were overlooked and will not be discovered until they cave at the surface. The number of these small identified shafts which may fail in the future is expected to be very small. The Anaconda Minerals Company has kept excellent records over the years and these records show the location of almost all of the mining activity that occurred in Butte. These records were made available for this study.

Little or no reclamation has occurred at most of the older mine sites and many shafts were simply boarded over when mining ceased. Over the years these mines gradually deteriorated and the shafts have periodically caved to the surface when timbers failed. The Anaconda Minerals Company has corrected many such problems as they have occurred by filling shallower shafts and by attempting to limit access to particularly dangerous mines by fencing. However, there are still a large number of potential public safety problems that must be considered for correction.

Each of the mines in the project area was examined in detail in the field in regard to shaft condition and general site conditions as related to waste dump volume and embankment slope, vegetative cover, runoff erosion problems, susceptibility to wind erosion, soil characteristics and site proximity to residential or business areas. Soil samples were collected from 26 dumps to allow development of a generalized understanding of waste dump characteristics as they relate to site revegetation. Soil samples also were collected from selected streets to assess potential impacts of deposition of waste dump material on streets and the subsequent local air quality problems.

Stormwater runoff water samples were collected to assess the impacts of waste dumps on the quality of runoff water which is discharged to the Metro Storm Drain and to Silver Bow Creek.

A socioeconomic study was conducted to obtain local resident opinions on abandoned mines in their neighborhood and to identify potential health and safety problems not previously detected.

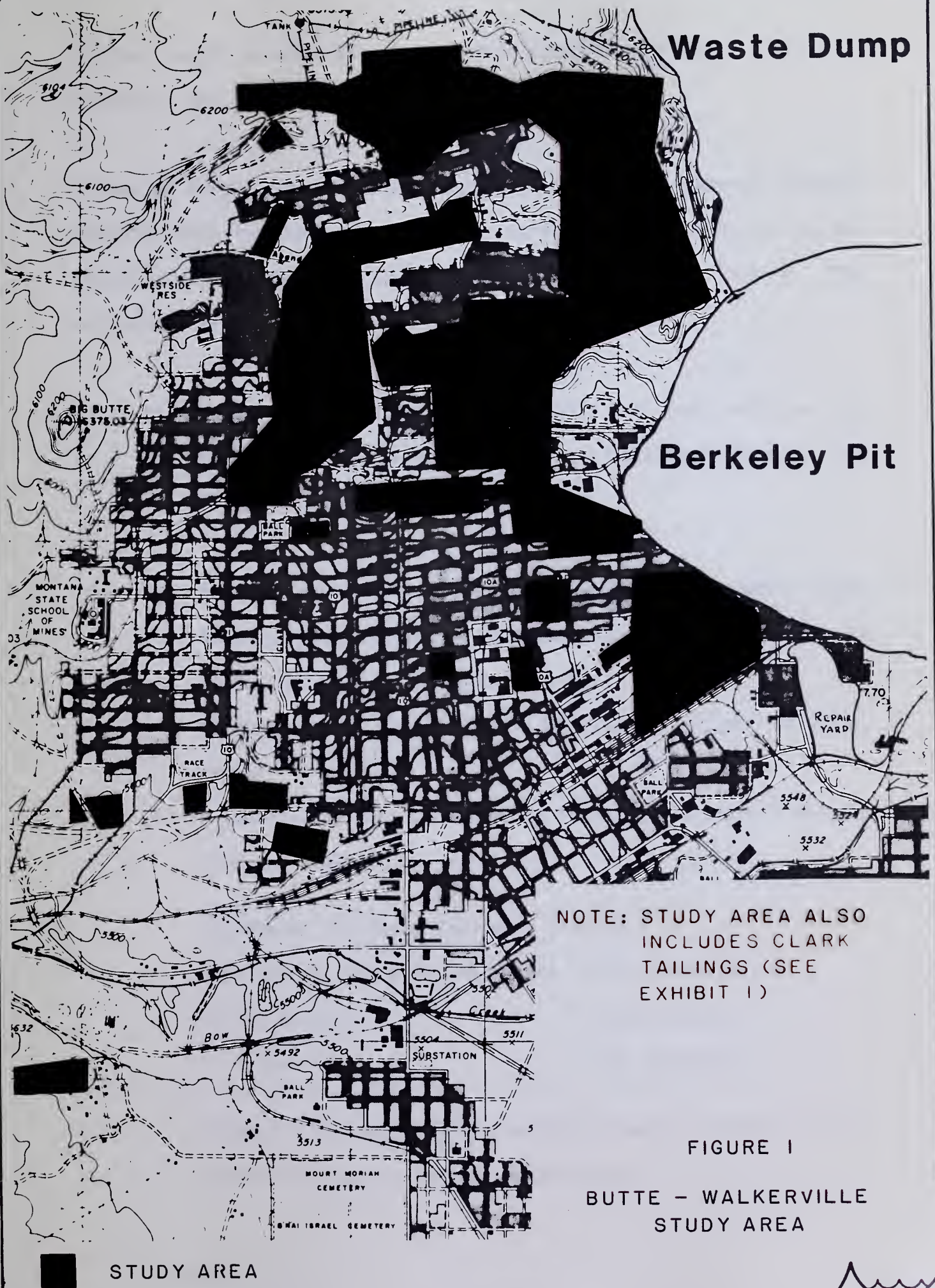
Information for Phase I of this project was obtained from many sources including the Technical Advisory Committee, area residents, detailed field surveys, Anaconda Minerals Company staff, first-hand knowledge from former Anaconda Minerals Company employees, Butte-Silver Bow government officials and from utility companies. Base maps used in this report were obtained from the Anaconda Minerals Company.

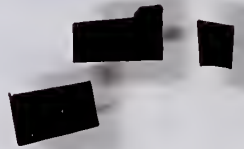
SITE DESCRIPTION

This report considers all mining and related properties in the Butte-Walkerville metropolitan area which are north of Timber Butte, east of Big Butte, west of the Berkeley Pit and south of the Alice Pit and waste dump (Figure 1 and Exhibits 1 through 5). Based on previous work (Hydrometrics, 1983), it is recognized that there are a large number of abandoned mines located peripheral to Butte and Walkerville, many of which pose a potential safety hazard. This study investigated only those mines in the Butte and Walkerville metropolitan area and abandoned mines and related disturbances peripheral to these communities were not included in this study.

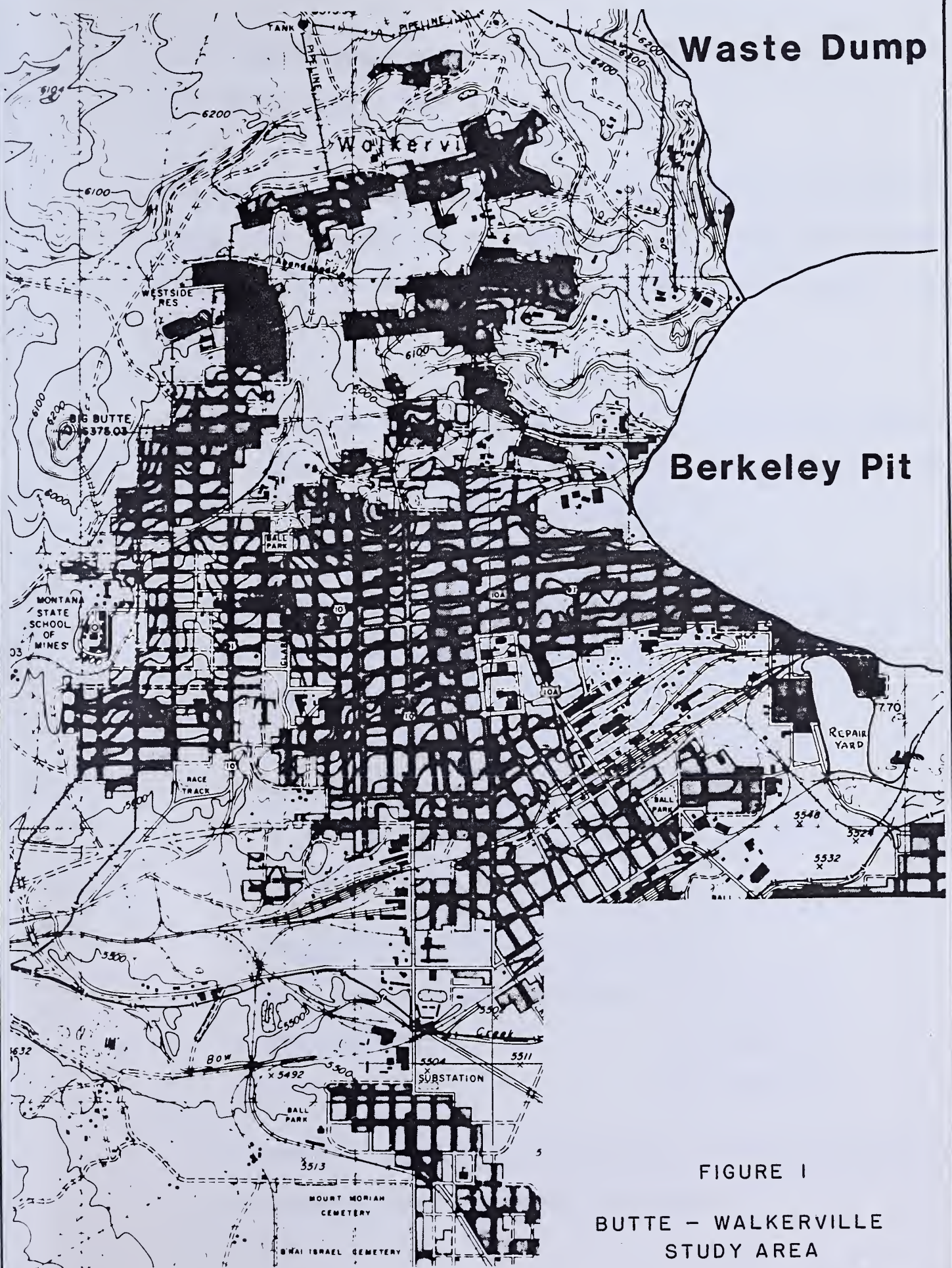
Initial project boundaries were recommended by DSL on July 26, 1983, and were based on a report by Rowling and McClernan (1981). Based upon previous work completed in the area (Hydrometrics, 1983) and upon detailed field surveys completed as part of this study, project study boundaries were expanded to include all known abandoned mining areas within the metropolitan area.

The project area does not include any inactive mines or related facilities which are under a valid operating permit and approved reclamation plan issued by DSL (the Anaconda Minerals Company holds the only valid permits in the immediate area). However, the project area does include all inactive mines outside Anaconda Minerals Company





NOTE: STUDY AREA ALSO
INCLUDES CLARK
TAILINGS (SEE
EXHIBIT 1)



Waste Dump

Berkeley Pit

FIGURE 1

BUTTE - WALKERVILLE
STUDY AREA

STUDY AREA

current permit boundaries but within Anaconda's main fence which runs along the east edge of Butte and Walkerville.

According to the property ownership maps kept by the Anaconda Minerals Company, they own both the immediate surface and the minerals on all except two of the mine properties included in this report. The exceptions are:

- 1) Anaconda owns the mineral rights but does not own the surface of Lot 50, Lizzie Lode, on East Park Street. The Hickey shaft is located on this lot.
- 2) Anaconda does not own the surface or mineral rights of the Ardsley Butte Mine. According to a title search done in 1981, the property is controlled by:
 - $\frac{1}{2}$ interest by Grant Deed - Winston F. Wright of Reno, Nevada;
 - $\frac{1}{2}$ interest by Lease & Option to Purchase - Winston F. Wright of Reno, Nevada.

The Option and Grant Deed were given by:

W. D. Murray and Lula Ann Murray	- 1/16 ownership;
Vivian McNeece	- 1/16 ownership
L. G. Tomich	- 7/8 ownership

There is no record that the option was exercised, but it could be traced by further abstracting.

IDENTIFICATION OF HAZARDS

The use of AML funds for noncoal reclamation is significantly limited by the Office of Surface Mining (OSM) criteria for noncoal projects. For purposes of Section 409(c) of Public Law 95-87, all noncoal projects must meet the following criteria:

- 1) There must be a clearly definable threat to the public health or safety;
- 2) The threat must present a danger that results in a high probability of serious physical harm to the health or safety of people;
- 3) The threat cannot await resolution until all coal projects have been completed;
- 4) The project must be necessary and appropriate to abate, control or prevent the threat; and
- 5) There is no private party legal responsibility under any other Federal or State law or county or municipal ordinance to abate, control or prevent the threat.

Based on these criteria, and in consultation with the Abandoned Mine Reclamation Bureau, threats to public health and safety in the study area were defined. The only clearly definable threat to public safety

in the study area are numerous mine shafts that are inadequately protected from public access. In Section 409 of Public Law 95-87, the Congress declares that:

"...open and abandoned tunnels, shafts, and entryways resulting from any previous mining operation, constitute a hazard to the public health or safety...."

The only clearly definable threat to public health is the air entrainment of mine wastes and tailings causing conditions detrimental to the human respiratory system. These conditions exist at numerous mine waste dumps, the Clark Tailings and at a few athletic fields in the Butte area where mine wastes are present on the fields.

PUBLIC SAFETY HAZARDS

A detailed inventory was made of all disturbed lands, mines and mine-related facilities in the Butte-Walkerville metropolitan area to identify all existing and potential public safety hazards related to abandoned mining activity. Each site was examined in detail in the field; extensive use was made of Anaconda Minerals Company records and former Anaconda Minerals Company employees having knowledge of the safety and closure conditions at any of the abandoned mines were interviewed. A total of 92 shafts were examined in the field or were evaluated by review of mining records. From these, 40 shafts were selected for reclamation due to their hazard rating. In addition to shafts, all disturbed lands, pits and mining-related facilities were examined in the project area. The walls of shafts in Butte are

supported by timbers. These wooden sets deteriorate with time and fail, allowing the rock walls to collapse. Timbers below the water table generally decay slowly but those above the water table can decay rapidly. Typically, shafts fail above the water table and often a funnel-shaped failure cone extends to the ground surface. The size of Butte shafts varies widely. Average main shaft size is about 9 by 25 feet. The smaller supply and air shafts are about 8 by 17 feet. Failure of these shafts can cause cone-shaped depressions of over 100 feet in width at the ground surface.

Records for several shafts were nonexistent or incomplete and it was not possible to determine in the field if these shafts are backfilled or bulkheaded. It will be necessary to drill some of these shafts to make the determination. On other shafts, the bulkhead is believed to be near the surface and can be exposed by removing the waste rock at the surface. Based on past experience, almost all abandoned shafts in the Butte-Walkerville area that are not backfilled are bulkheaded at or near the surface with wooden planking. This planking typically is covered over with waste dump material that is graded flat, giving no clue regarding the presence of an underlying shaft. As the timber and planking in these shafts decays and weakens over the years, a sudden failure often occurs. For many years, the Anaconda Minerals Company had a program of filling these shafts as they failed and opened at the ground surface.

Based on detailed site investigations, the estimated safety hazard at each site was ranked on a scale of one to five. Sites ranked one were considered safe with no existing safety problems with essentially no probability of a future safety problem occurring. Sites ranked five were considered serious safety hazard requiring immediate attention. A deep open shaft adjacent to a residential neighborhood would be ranked five. Intermediate rankings were assigned where appropriate. The safety hazard ranking system used is subjective and considered such variables as proximity to areas used by children, existing fencing or other access control measures, size and depth of shaft, debris left on site, embankment steepness and likelihood of slope or bulkhead failure. Sites ranked three, four or five are recommended for reclamation consideration (Table 1). Appendix A contains a detailed discussion of the public safety assessment. A field inventory for each site is included.

In addition to abandoned shafts, adits, drifts and pits, other potentially hazardous situations were examined. These included structural facilities such as buildings and headframes in poor condition, steep banks and subsidence effects on public utilities and buildings. The integrity of structural facilities and steep banks or slopes was included with the assessment of shafts, adits, drifts and pits.

City officials were contacted concerning past problems with personal injury related to unauthorized activities at abandoned mine sites in the metropolitan area. None were identified; however, concern was

TABLE 1. ABANDONED MINES RECOMMENDED FOR RECLAMATION

The following are forty shafts and two pits that are considered to have a hazard rating of three to five inclusive. Some of the shafts can be made safe by a "back filling" process whereas a capping or plugging process is required on the rest.

Belmont Area		
Mine Shaft Name	Hazard Rating	Method of Protection
Belmont	4	Capping
Otisco (Air)	4	Back filling
Colorado	4	Capping
Hoy	3	Back filling
Hesperus (area)	3	Back filling
Mt. Con - Steward Area		
Parrott (Air)	4	Capping
Original	5	Capping
Mt. Con	4	Capping
Little Mina	4	Back filling
Buffalo	5	Capping
Original #6	4	Back filling
Benham	3	Back filling
Steward	4	Capping
Anselmo - Lexington Area		
Lexington	5	Capping
Anselmo	5	Capping
West Gagnon	3	Capping
Missoula (Ryan)	3	Back filling

Table 1, continued

Walkerville Area		
Rising Star #1	4	Back filling
Rising Star (Lessee)	4	Back filling
Rising Star (Main)	3	Back filling
Goldsmith (Tong)	3	Back filling
Paymaster (Lease)	3	Back filling
Eveline	3	Capping
Venus	3	Back filling
Moose	4	Capping
Moose (Auaria)	3	Back filling
Diamond	5	Capping
351 Raise-Magna Charta	4	Back filling
West Gray Rock	5	Capping
Valdemere	3	Back filling
Belle of Butte	4	Back filling
Miscellaneous Areas		
Mary Louise	4	Drill & Cap
Ardsley Butte	3	Back filling
Bonanza	4	Back filling
Anselmo Air	3	Back filling
Travona	5	Capping
Ophir	4	Back filling
Emma	5	Capping
Britania	3	Back filling
Open Pits		
Syndicate	4	Partial filling
Alice	5	Partial filling

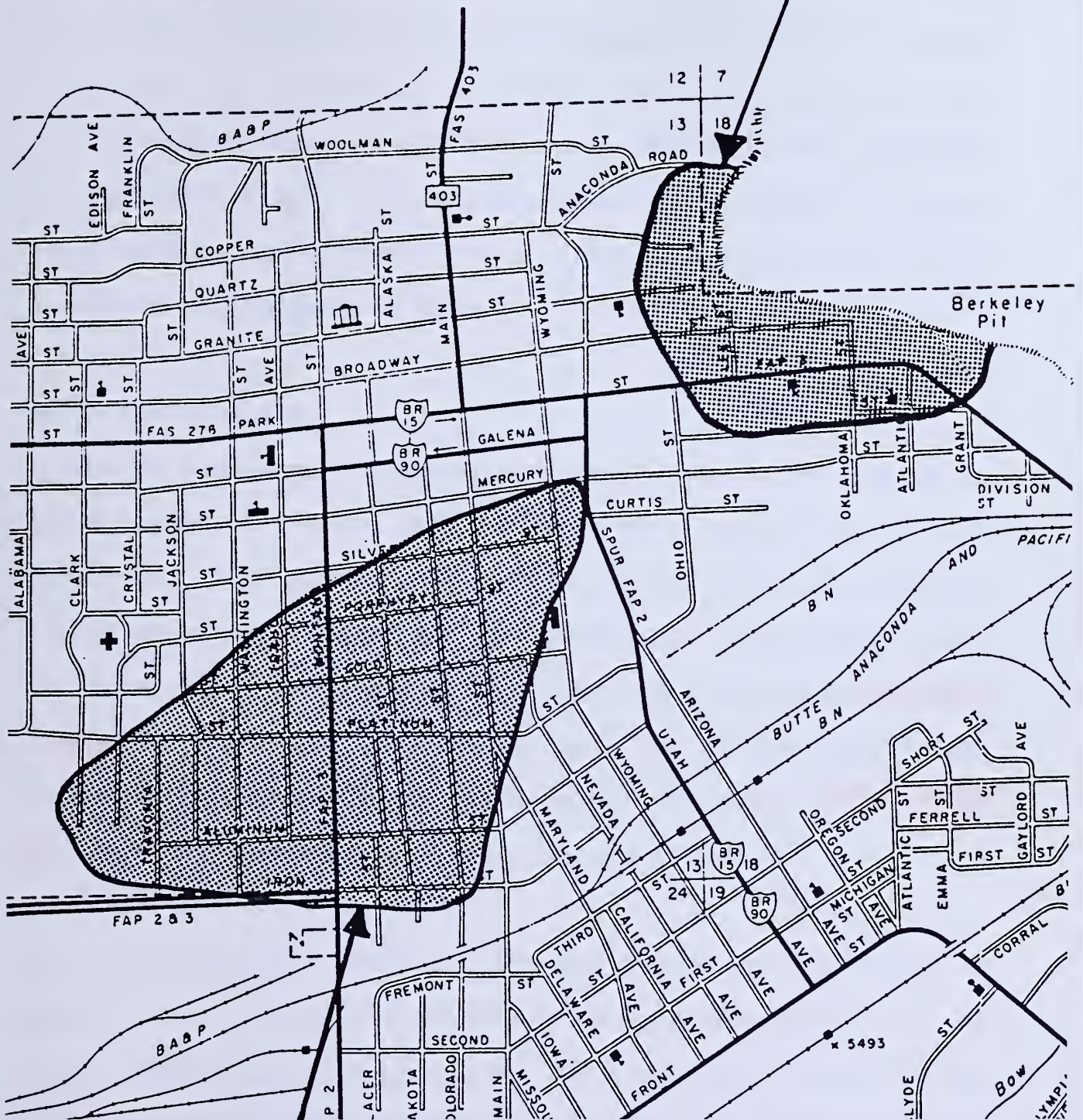
expressed about the very real risk which exists at the many sites in the area (Lowney, 1984, pers. comm.).

Subsidence was a significant problem in Butte when underground mining was active. Locations at which significant subsidence occurred are the area between the Emma and Travona Mines, the area south of the Kelley Mine and west of the Berkeley Pit (Figure 2). Subsidence has also occurred peripheral to the Alice and Syndicate Pits.

When the Emma and Travona Mines were closed in 1959, the rate of subsidence rapidly diminished. Subsidence in the area is not now considered a significant problem although subsidence continues to occur and repairs to utilities (water, sewer and natural gas) are infrequently required (Patterson, Mehrens, LeVeaux and Vivian, pers. comm., March 14, 1984).

Subsidence due to mining from the Kelley Mine occurred primarily between the 1940's and 1960, when mining terminated. The magnitude of subsidence was not as extensive as occurred in the area from the Emma to the Travona but, some utility damage was sustained. No recent subsidence of the area has been noted and the surface is now almost all owned by the Anaconda Minerals Company. This conclusion is based on personal knowlege of the history of the area (Dave Piper, Piper and Associates, examination of Anaconda Minerals Company surface ownership maps and on recent discussions with utility personnel (referenced above).

APPROX. BOUNDARY OF KELLEY BLOCK CAVE SUBSIDENCE



APPROX. BOUNDARY OF EMMA-TRAVONA SUBSIDENCE

FIGURE 2

MAJOR MINE SUBSIDENCE AREAS IN BUTTE

Subsidence peripheral to the Alice and Syndicate Pits will continue to occur until pit walls reach the angle of repose (about 38 degrees). The likelihood of homes or utilities being affected by this subsidence is expected to be nil. Open pit subsidence along steep walls can be controlled by partial backfilling. Appendix B contains a detailed discussion of subsidence in Butte.

PUBLIC HEALTH HAZARDS

A detailed assessment was made of available air quality information for the Butte area including health effects of air pollution on Butte residents. Also examined was the toxicology of metals commonly contained in mine wastes and low grade ores. Dust samples were collected from street locations below eroding waste dumps, baseball fields and the Clark Tailings and were tested for constituents considered detrimental to the human respiratory system (Tables 2 and 3). Sampling locations are shown on Exhibits 2 through 5.

The Butte-Walkerville area has a long and colorful history related to over 120 years of intensive mining and mining-related activity in the area. This activity apparently has had significant effects on the public health of area residents. As a result, a number of health studies have been conducted. However, none of the previous studies were specifically directed towards examining the public health impacts and implications of abandoned waste dumps, open pits and tailings located in and peripheral to the Butte-Walkerville area. Therefore, sources of air quality degradation, including mining areas under valid

TABLE 2. DESCRIPTION OF SURFACE DUST SAMPLING PROGRAM

A. Sweeping of Butte City Streets

<u>Sample Number</u>	<u>Location</u>	<u>Remarks</u>
1	South of Belmont Mine Area	6 blocks sampled
2	East Mercury Street, Belmont Mine to Colorado Mine	7 blocks sampled
3	East and South of Emma Mine	2 blocks sampled
4	West and South of Ophir Dump	2 blocks sampled
5*	North, East and South of Travonia Mine	4 blocks sampled
6*	Star West Dump Area	3 blocks sampled
7	Alley, South of Original Mine	3 blocks sampled
8	Woolman Street, South of Steward Mine	3 blocks sampled
9	Buffalo Street, Below Mtn. Con Mine	5 blocks sampled
10	South of Buffalo Mine, Syndicate Open Pit	7 blocks sampled
11	Caledonia Street, South of Anselmo Mine	3.5 blocks sampled
12	Road West of Alice Open Pit Dump	7-8 blocks sampled
13	East and West of Lexington Mine	8 blocks sampled

B. Surface Sampling with Industrial Vacuum Cleaner

<u>Sample Number</u>	<u>Location</u>	<u>Remarks</u>
14	Clark Tailings Area	On 250-300 foot grid
15	Little League Baseball Field One Block South of Anselmo Mine	25 sample points
16	Little League Baseball Field on Missoula Avenue	16 sample points
17	Ball Field/Playground Area South of Alice Open Pit Dump	20 sample points

*Samples 5 and 6 were combined into one composite sample for chemical analysis purposes.

TABLE 3. CHEMICAL ANALYSIS OF DUST SAMPLES FROM CLARK TAILINGS AREA, STREET SWEEPINGS AND PLAYGROUNDS

Sample Number	Associated Mining Area	Chemical Analysis of Minus 45 Micron Dust Screened Through Minus 325 Mesh Tyler Screen (µg/g)														Total Percent Ident.
		As	Bi	Ca	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn	SO ₄	SiO ₂ (%)	Non Vol. H.C.	
1		181	<50	46,500	12.6	425	1,410	61,800	1,010	55	868	1,970	34,100	47.3	1,900	62.33
2		141	<50	45,800	11.4	400	1,330	60,300	1,070	53	742	20,600	36,300	33.9	2,400	50.81
3		131	<50	54,000	19.5	790	1,500	98,000	9,580	93	1,510	5,450	60,900	38.2	4,500	61.85
4		1,580	60	29,000	34.8	88	10,500	87,500	6,600	<50	1,070	8,090	112,000	43.8	1,200	69.58
5 & 6		271	<50	38,900	29.8	242	1,100	52,600	19,800	<50	2,240	8,240	49,100	36.3	2,000	53.76
7		475	<50	60,800	38.1	490	4,400	55,800	1,900	61	2,160	8,930	56,300	42.5	4,800	62.12
8		170	<50	43,300	13.0	253	2,350	60,800	1,400	<50	724	1,930	51,500	43.0	1,800	59.43
9		72	<50	24,000	22.6	960	2,100	76,800	2,300	<50	4,450	5,300	86,300	49.9	1,600	70.30
10		459	<50	37,500	20.9	147	1,830	59,400	1,380	<50	1,380	4,850	48,800	47.6	4,000	63.59
11		284	<50	46,100	24.7	314	1,550	59,200	2,000	<50	1,430	5,500	56,300	49.4	4,000	67.08
12		80	<50	35,300	12.7	118	256	53,000	4,550	<50	1,230	2,380	37,500	40.9	1,900	54.54
13		46	<50	38,300	22.3	129	485	53,800	3,630	<50	1,430	3,880	43,500	41.6	1,800	56.31
14		1,600	<50	7,030	31.2	15	562	48,500	34,200	<50	2,700	10,300	134,000	68.4	200	92.32
15		398	<50	23,100	25.1	64	1,680	38,600	3,050	<50	604	6,740	36,000	44.4	100	52.21
16		240	<50	25,000	22.4	58	290	44,400	5,330	<50	798	6,880	33,000	44.0	--	55.61
17		106	<50	31,000	16.4	72	279	60,300	5,180	<50	874	2,980	38,800	19.9	400	33.91

operating permits, unpaved streets and abandoned mine areas within and peripheral to the study area were not distinguished. Further, extensive changes such as the suspension of all Anaconda Minerals Company mining operations in 1983 have occurred since these air studies conducted. Therefore, much of the information contained in these studies is of historical interest but do not directly relate to present conditions. Results of these previous studies, however, and the general relationships between air pollution and human health is of importance in the Butte area and a useful perspective can be gained by review of these studies.

The literature shows Butte's population has a higher than normal incidence of lung cancer and respiratory system diseases. The Montana Air Pollution Studies (MAPS) were mandated and funded because of unusually high death rates from chronic pulmonary disease and lung cancer in several Montana counties and because many researchers feel that increased air pollution levels can cause or contribute to the severity of certain lung diseases. The Montana Air Quality Bureau recommended the extensive MAPS study to determine the relationship between air pollution and human health.

The MAPS studies concluded that children with the poorest pulmonary function performance were exposed to the highest levels of particulates and sulfur dioxide. Also, adults with chronic obstructive pulmonary disease had decreased pulmonary function and increased coughing, wheezing and breath shortness with increasing air pollution levels.

Butte children showed elevated urine mutagen levels specifically in certain areas of residence. The etiology of the diseases in Butte residents was not defined; however, a review of death certificates and records revealed statistically higher death rates from asthma, chronic bronchitis, emphysema, cerebrovascular disease and lung cancer in Silver Bow County than in the general Montana population. Death rates due to cancer of the respiratory system in Silver Bow County were almost eighty percent (80%) greater than the Montana death rate per 100,000 population for 1969 to 1973. For the same period, respiratory diseases were more than 50 percent (50%) higher than the corresponding Montana rate.

Community air pollution appears to have contributed to the higher than average disease and death rates. Overall, the MAPS program confirmed the proposition that there is an association between air pollution and pulmonary performance and increased air pollution levels cause a decrease in lung function (Montana Air Pollution Study, 1979 to 1981).

Epidemiological studies of children and adult populations in industrialized countries have lead researchers to conclude there is a definite correlation between air pollution and human health. Specifically, there is a definite correlation between the incidence of lung cancer and smoking, air pollution and the use of new industrial and agricultural chemicals in the environment. Available evidence suggests reduced respiratory function in children caused by air pollution may increase the risk for future respiratory problems as

adults. Continued chronic exposure to significant air pollution increases the risk of serious respiratory illness in children. Two to three percent of all human congenital defects may be attributed to drugs and environmental chemicals (Fraumeni, 19__).

Arsenic, cadmium, chromium and nickel are all present in the Butte environment. All have been implicated as human carcinogens and, with the exception of arsenic, have induced cancer in animals. Iron, lead and zinc are suspected human carcinogens and have caused cancer in experimental tests. These metals are also present in the ambient Butte environment. Free silica is present in high concentrations in Butte's ambient dust and a distinct relationship between iron and free silica in dust has been documented. Inhalation of iron dust causes a benign pneumoconiosis called siderosis. However, if other dusts, particularly free silica, are present, fibrotic pulmonary changes occur. Thus, the presence of free silica in addition to iron induces more significant lung changes. This additive or possibly synergistic relationship is significant in an ambient situation where both contaminants occur together and in the presence of even more pollutants.

The community of Butte-Silver Bow has a statistically high rate of respiratory and circulatory disease and death. The preponderance of evidence shows there is a strong correlation between air pollution and disease of the respiratory system.

The presence of potential human carcinogens, the potential for additive or synergistic toxicologic reactions between the air pollutants and the potential or actual chronic long-term public health exposure are matters of significant concern. These factors, coupled with the increased incidence of lung carcinoma in Butte-Silver Bow and the definite association between community air pollution and high respiratory disease and cancer documented in the literature, weigh as heavy circumstantial evidence of the potential public health concern present in Butte.

The cause of cancer is, at the current knowledge level, a multiplicity of factors. Some urban pollutants have known carcinogenic potential. Additionally, many air pollutants are respiratory irritants and may facilitate the deposition and subsequent reaction of carcinogenic compounds. Irritants may provide sensitive sites on the respiratory tract.

The presence of carcinogens, their deposition and retention in the respiratory system and individual factors of susceptibility are important parameters in cancer development. However, at what level of concentration environmental carcinogens must be present in order to induce cancer is not known. Most researchers and scientists feel only minute concentrations of a carcinogen are necessary to disease development, but the toxicological implications of environmental pollutants in general and specifically carcinogens are undefined. In order to protect public health, it is probably appropriate to take a very

conservative approach in evaluating the consequences of ambient pollutant exposure.

Evidence is available to show the adverse consequences of air pollution on public health, specifically changes in pulmonary performance and lung cancer. Public health practice and preventative medicine both strive to prevent the development of disease and take adequate measures beforehand to control the progress of disease. Adequate information is available to indicate the need to control and eliminate air pollution for the betterment of any community and the public's general health.

Mining-caused surface disturbances in the study area include waste rock dumps, two open pits and two tailings ponds⁽¹⁾. Waste material associated with the underground mines ranges from a few hundred cubic yards (cy) up to an estimated 815,000 cy in the Mountain Con dumps. The Alice Pit dumps contain about 5,560,000 cy of material. The Clark Mill tailings site is estimated to contain one million tons. The surface area of abandoned mine lands studied in the project area is about 350 acres.

The barren slopes of many of the waste dumps are being eroded. This eroded dump material often is deposited on the city streets. An additional source is sanding of city streets during winter months.

(1) Only the Clark Tailings are considered in this study. the Colorado Tailings have been declared a Superfund site under RCRA and have been excluded.

Material deposited on city streets is broken down into fine dust by vehicular traffic and becomes airborne due to increased turbulent air from the vehicles or natural winds. Much of the material also is carried into the Butte-Silver Bow storm sewer system. The Montana/EPA agreement on management and administration of Montana's environmental programs for 1983 lists the principal sources of suspended particulate in the Butte area as the mining operations and the local streets.

A surface dust sampling and chemical analysis program was conducted at 17 locations in the study area that are potential contributors to airborne dust. The original sources of the dust are abandoned mine land areas. The chemical analysis of the fraction of the dust that could become airborne, along with an assessment of the potential negative effect on the health of the local population indicate strong support for eliminating erosion of abandoned mine lands that are potential contributors of toxic contaminants into the ambient air. Significant concentrations of arsenic, chromium, iron, manganese, lead, zinc, free silica and sulfate were found in the street dust below the following mine dumps:

- 1) Ophir Mine
- 2) Anselmo Mine
- 3) Emma Mine
- 4) Original Mine
- 5) Mountain Con Mine
- 6) Travoni Mine/Star West Dump Area

Therefore, a stabilization/reclamation program is recommended for these mine dumps in order to reduce the amount of material eroded from the dumps and deposited on city streets. In addition, it is recommended that three baseball fields (Table 4) be covered with suitable soil to minimize respiration and ingestion of potentially toxic mine wastes. There are other barren playgrounds in the study area but these have not been studied in sufficient detail to develop a recommendation.

TABLE 4. PLAYGROUNDS NEAR MINE WASTE DUMPS

<u>Location</u>	<u>Adjacent Mine Waste Dump</u>	<u>Playground Constructed on Waste Dump</u>	<u>Surface Condition</u>	<u>Dust Sample Collected</u>
Little League baseball field one block south of Anselmo Mine.	Anselmo	No	Barren	Yes
Little League baseball field on Missoula Ave.	Syndicate	Yes	Barren	Yes
Ballfield/play- ground area south of Alice Pit	Alice	Yes	Barren	Yes
Playground on B Street near Missoula Gl.	Lexington	No	Barren	No

Runoff erosion of waste dumps for the Colorado, Little Mina and Buffalo Mines has been observed in the field during this study and confirmed in conversations with city staff (Mehrens, pers. comm., 1983). Street dust samples were not collected below these waste dumps but soils

information collected by Hydrometrics (1983) and as part of this report suggests metal concentrations would be high for material eroded from these sites.

The dust sample obtained from the Clark Tailings contains significant concentrations of arsenic, iron, manganese, lead, zinc, sulfate and free silica. However, contribution of the Clark Tailings to local air pollution problems has been periodically observed but there has been no air quality monitoring peripheral to the site.

Approximately 60 percent of the population living adjacent to the abandoned mine land areas and who responded to a socioeconomic survey indicated abandoned mine land sites in their neighborhood were sources of dust. Responses indicate sources of dust from mine areas are (1) windblown and/or (2) material eroded from the mine dump areas, deposited on downgrade sites and entrained into the ambient air by vehicles, other community activities and natural winds.

A detailed examination of natural radiation sources was beyond the scope of this study. However, a radiation problem has been documented by the Montana Department of Health and Environmental Sciences and is summarized in the detailed air quality assessment report (Appendix C).

WATER RESOURCES

The entire project area is within the Silver Bow Creek drainage and is divided north and south by Interstate Highway 90 (Exhibit 1). The project area south of the highway is drained by Grove Gulch. Grove Gulch is an intermittent tributary of Silver Bow Creek and has been extensively impacted by residential development and the placement of the Clark (Timber Butte) Tailings in the Grove Gulch drainage early in this century.

The project area north of I-90 is drained by six storm sewer systems (Exhibit 6) which were installed as the city of Butte developed. The earliest systems were installed prior to 1900 and serve the older industrial, business and residential area of Butte and Walkerville which is located generally east of Excelsior Avenue. Much material eroded from inactive mine waste rock dumps is transported into these older storm sewer systems. For purposes of this report, newer storm sewers west of Excelsior Avenue are collectively referred to as the West Side Storm Drain System. This west side system drains a residential section with essentially no past mining activity and consists of several individual systems with comparatively small drainage areas.

Water quality sampling in the project area has been limited and most sampling and analysis have been conducted by the Anaconda Minerals Company. There has been no sampling of runoff by the Montana Bureau of

Mine and Geology (Patton, pers. comm., March 1, 1984), the U. S. Geological Survey (White, pers. comm., March 1, 1984), the Water Quality Bureau (Greene, pers. comm., March 1, 1984) or the Butte-Metro Sanitary Sewer District (Pasco, pers. comm., March 1, 1984).

GROVE GULCH

Surface Water

Grove Creek begins in mostly rolling open range land approximately four miles southwest of the city of Butte and discharges to Blacktail Creek approximately 75 feet upstream of the Kaw Avenue overpass. Vegetation cover in the watershed upstream of the Clark Tailings is considered fair to good. However, the watershed is considered to be a heavy sediment producer (SCS, 1980). Based on cooperative water quality sampling and analysis by the Soil Conservation Service and the Anaconda Minerals Company (Hydrometrics, 1983), Grove Creek upstream of the Clark Tailings and City-County Landfill (Exhibit 5) has concentrations of trace metals which, except for iron, typically are less than Federal drinking water standards for public water supplies (Table 5). Iron concentrations frequently exceed the recommended public water supply limit of 0.3 mg/l.

The water quality of Grove Creek downstream of the Clark Tailings is degraded. Hydrometrics (1983) reported significantly greater arsenic, copper and zinc concentrations below the tailings⁽¹⁾ and suggested the

(1) Federal drinking water standards were not exceeded except for iron and manganese.

TABLE 5
FEDERAL DRINKING WATER STANDARDS
FOR PUBLIC WATER SUPPLIES

<u>Parameter</u>	<u>Maximum Contaminant Levels for Inorganic Chemicals (mg/l)</u>
<u>Primary Standards (1)</u>	
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate as N	10.
Selenium	0.01
Silver	0.05
Fluoride	1.4 - 2.4 ⁽²⁾
<u>Secondary Standards (3)</u>	
Chloride	250
Color	15 (color units)
Copper	1.0
Corrosivity	Non-corrosive
Iron	0.3
Manganese	0.05
Odor	Threshold odor number of 3
pH	6.5 - 8.5 Standard Units
Sulfate	250
Zinc	5.0
Total Dissolved Solids	500
Foaming agents	0.5

(1) 40 CFR Part 141 (Federal Register, Vol. 40, No. 248, December 24, 1975) and (Administrative Rules of Montana) ARM 16-2.14(10)-S14381.

(2) Maximum allowable concentration depends on annual average of maximum daily air temperatures at site of supply.

(3) 40 CFR Part 143 (Federal Register, Vol. 44, No. 140, July 19, 1979).

discharge of shallow, poor quality groundwater underlying the landfill and tailings areas to the creek plus urban activities in the watershed, are the probable causes of the water quality degradation.

✓ Overland runoff from the Clark Tailings is discharged to Grove Creek. The quality of this water is very poor and contains very large concentrations of cadmium, copper, lead, manganese, iron, zinc (all greatly exceeded Federal Drinking Water Standards) (Hydrometrics, 1983).

Groundwater

The volume of groundwater moving through the Grove Gulch alluvium is thought to be small. However, the extent and nature of alluvial groundwater degradation is not well defined in the vicinity of the Clark Tailings. In conjunction with the Grove Creek Flood Prevention Project, the SCS installed seven hydrological monitoring wells in May 1979 to assess impacts of the city-county landfill and the Clark Tailings on the local groundwater system.

Groundwater upgradient of the landfill and the Clark Tailings is of excellent quality and meets Federal drinking water standards for public supplies except for manganese (Hydrometrics, 1983). Groundwater downgradient of the Clark Tailings is a very poor quality water with very high iron, manganese and zinc concentrations. Water level measurements by SCS staff show the Clark Tailings probably are above

the local groundwater table during all portions of the year (Hydrometrics, 1983).

STORM DRAIN SYSTEMS

Warren Avenue

The sampling of storm water runoff in Butte has been very limited. The Anaconda Minerals Company collected some samples from the outfall in 1979. Grab samples were collected as part of this study in October 1983 near the end of a steady light rain which lasted about 24 hours and had a total accumulation of 0.32 inches at the airport. October 1983 sampling sites are shown on the exhibits.

The Warren Avenue system drains an industrial area on the east side of Butte. The outfall discharges to the Metro Storm Drain and is behind and upstream of the Butte Civic Center on Harrison Avenue. The Belmont and several other inactive mines and waste dumps are in the drainage.

Water quality sampling by the Anaconda Minerals Company and by Hydrometrics (Appendix 1) shows the quality of water discharged by the Warren Avenue system to be variable and to contain large concentrations of copper, iron, manganese and zinc. The apparent source of these metals is the mine waste dumps in the drainage. The outfall sample collected in October 1983 shows the metals are contained primarily in the suspended sediments. However, a sample of runoff collected just downstream of several waste dumps (Site 003 on Exhibit 6) shows water

in recent contact with acid waste rock contains moderate to high concentrations of cadmium, copper, lead, iron, manganese and zinc.

Anaconda Road - Butte Brewery

This system drains an extensive industrial and commercial area adjacent to downtown Butte and includes a large area within the Anaconda Minerals Company boundary fence. Some of this area is under a current Montana Department of State Lands operating permit and reclamation plan. The Anaconda Road - Butte Brewery storm sewer system discharges to the Metro Storm Drain at Harrison Avenue. The drainage area also contains numerous inactive mines and associated waste dumps which are outside Anaconda's boundary fence.

Significant volumes of waste are eroded from waste dumps in this drainage area and are carried to low points and to the drain system where deposition occurs. Contact with this eroded material adversely affects the quality of runoff and results in the movement of dissolved and suspended metals to Silver Bow Creek.

Buffalo Gulch

The Buffalo Gulch storm drain system was constructed prior to 1900 in the drainage bottom of Buffalo Gulch, a historic ephemeral tributary to Silver Bow Creek. As the community of Butte grew, fill from the excavation of building basements was used to fill in and obliterate topographic evidence of the historic gulch in the downtown area. Within the downtown area, a number of buildings have been constructed

over the storm drain. These buildings may be affected if this storm drain were to fail.

The Buffalo Gulch system begins in the residential area known as Centerville. the system follows the alignment of the historic drainage in this area, is mostly piped and is reasonably well vegetated although there are some barren waste dump areas in the vicinity of the St. Lawrence and Mt. Con Mines.

The central portion of the system is open and uses the historic natural stream channel. The condition of the channel is very poor in this section and it has been extensively eroded (to bedrock at some sites) and is the site of movement of large volumes of sediment. This central portion of the drainage contains extensive barren waste dumps and otherwise barren soil surface caused by extensive past mining. There is a small residential area below Ruby Street which suffers from periodic flooding and sediment deposition.

Runoff was originally collected and transported through this section of the storm sewer by a wooden box culvert. Most of the box culvert is either washed out or is rotted away and the present stream channel is now well below the original grade of the box culvert as evidenced by the few sections which remain. The system has not functioned in many years.

The Buffalo gulch storm system discharges to Silver Bow Creek just below the Metro Storm Drain - Blacktail Creek confluence and just upstream of Montana Street.

The Anaconda Minerals Company collected three water quality samples at the Buffalo Gulch storm system outfall at Silver Bow Creek in 1979. Laboratory analysis of these samples show generally low concentrations of copper, iron and zinc. The only other sampling of runoff in the Buffalo Gulch system was conducted in October 1983 as part of this study. The 1983 sampling was conducted at intermediate locations in the drainage to more accurately reflect the quality of water associated with runoff from mine disturbed land and from waste dumps. Examination of the 1983 water quality data shows that water in recent contact with mine wastes in the upper portion of the drainage (sample sites 006 and 007) contains generally low concentrations of both dissolved and suspended metals in contrast to runoff from mine dumps near the Berkeley Pit. Runoff from the Original Mine (site 005) was of somewhat poorer quality.

Missoula Gulch

Missoula Gulch begins north and west of Buffalo Gulch and immediately south of the Alice Pit and dump. Except for a small portion in Walkerville, the drainage is not piped until it reaches the Anselmo Mine area. This upper portion of the drainage has been extensively disturbed by past mining and significant erosion of waste dumps in the drainage is evident.

Missoula Gulch between B Street (in Walkerville) and Missoula Avenue (in Butte) has been eroded to bedrock by runoff. Remains of a wooden box culvert just below B Street are several feet higher than the existing stream channel bottom and show the erosion to be relatively recent. The box culvert apparently carried Missoula Gulch runoff in the early part of this century.

Water quality samples were collected of runoff at three locations in the Missoula Gulch drainage. Laboratory results show runoff from mine dumps upstream of Walkerville to be generally low in metals and of much better quality than runoff from mine dumps near the Berkeley Pit. Runoff from the Alice Dump contains some manganese and zinc but is otherwise low in dissolved metals. Runoff from the Anselmo Mine was of poor quality and contained significant concentrations of cadmium, manganese and copper.

Runoff discharged from the Missoula Gulch outfall at Highway 10 and Excelsior Avenue was of fair quality and probably reflected dilution by runoff from the residential area below the Anselmo Mine.

Flow measurements made at sampling sites and the outlet of the Syndicate Pit shows streamflow is lost to fractured bedrock underlying the gulch between Walkerville (B Street) and the Syndicate Pit.

West Side Storm Drains

Mining disturbances in this area have been very limited. Therefore, the quality of water discharged by these storm drains was not examined.

SOCIOECONOMIC ASSESSMENT

Until recently, mining was a major employer in the city of Butte and in Silver Bow County. As a major employer, mining also has had a major influence on area population. From 1880 to 1920, economic expansion in Butte coincided with heavy employment growth caused by the development of several new mines and smelters in the area. About 12,000 men comprised the mining industry work force in Silver Bow County in the early 1900's. This period was followed by a persistent decline in mining industry employment and in county population which has continued to the present. From 1940 to 1980, county population declined 28 percent and employment in the mining industry decreased 75 percent. During the same period the population of Montana increased by 41 percent.

To obtain personal opinions regarding abandoned mines in residential neighborhoods, a questionnaire was mailed to about 40 percent or a total of 125 households located near abandoned mines. Sixty-eight (58 percent) of the questionnaires were completed and returned. Based on results obtained from the questionnaire, residents near abandoned mined lands see the sites as a detriment to the neighborhood in terms of land values and public safety and are in favor of reclamation. The median value of owner-occupied housing units in Butte is \$31,600 (1980). the median value of owner-occupied housing units statewide is \$46,500 (1980). The value of houses in the project area was adversely influenced by the presence of abandoned mine sites. However, many

houses located near abandoned mine sites in the North Butte area are considered low-value properties and reclamation would result in only limited enhancement of property valuations.

The socioeconomic assessment (Appendix E) provides a detailed discussion of the household socioeconomic survey and describes socioeconomic conditions in Butte.

SOILS

Waste dumps in the Bute area are typically very acid and have high concentrations of metals. Waste dumps are steep, barren of vegetation and are subject to erosion. Some dumps consist of surficial waste rock and have not developed a low pH, but are barren of vegetation due to steep slopes and low water-holding capacity of the material. the high sulfide content of waste materials causes a low pH to develop as a result of oxidation. As a result, elements such as zinc, cadmium, copper and arsenic commonly present in the dumps, are readily dissolved and flushed from waste dumps and tailings by precipitation.

Water Erosion is a problem at many of the waste dumps and has been extensive on the Clark Tailings. Many waste dumps are at the angle of repose (32 degrees) but in some cases their slope length is so short that little erosion has occurred. Larger waste dumps like the Alice generally have a severe erosion problem with estimated soil loss at more than 30 tons per acre per year. Tailings surfaces are nearly level and thus only the edges of tailings have sufficient slope to create erosion problems. Large gullies have incised several hundred feet into of the Clark Tailings.

SOIL CHARACTERISTICS

An intensive field survey of inactive waste dumps was conducted to assess potential techniques available for site reclamation (Appendix F). Twenty-six soil samples were collected; 13 of these samples were

examined in the laboratory (Tables 6 and 7). In addition, soils data from previous studies (Hydrometrics, 1983) were also useful in an analysis of quality of dump materials.

Waste dump materials are commonly high in rock fragment content (>2 mm size particles) which ranged from 20 to 70 percent by weight. Waste materials ranged from 55 to 85 percent sand, with clay ranging from 3 to 23 percent. Available water-holding capacity of the waste and tailings materials is expected to be less than 0.5 inches per foot of soil.

Acid dumps are the dominant waste materials in the Butte metro area comprising around 60 percent of the total waste. They are characterized by a pH of 2 to 4, EC (electrical conductivity) of 1 mmho/cm or higher high concentrations of soluble copper, manganese and zinc which would prohibit plant growth, and a distinctive yellowish-brown colored surface. Acid wastes have from 60 to 85 percent sand and 30 to 70 percent rock fragments making their water-holding capacity less than 0.5 inches/foot of soil depth.

Non-acid waste dumps are less common than acid dumps but can be mixed in occurrence with them at any particular site. They comprise about 15 percent of the total waste in the project area. Non-acid dumps have a pH from 5.5 to 8.5, have 60 to 85 sand and 20 to 60 percent rock fragments, making their water-holding capacity less than 0.5 inches per foot. They are generally barren of vegetation due to their steep

TABLE 6. SOIL PHYSICAL CHARACTERISTICS OF WASTE MATERIALS

Sample Location	Location	Depth (in.)	Sand -----	Silt -----	Clay -----	Rocks -----
			-----%			
1	Alice Dump - Upper SE	0 - 6	84.8	10.0	5.2	31.7
2	Minnie-Irvin Near Street	0 - 6	82.8	10.0	7.2	21.2
3	Goldsmith Gray Material	0 - 2	60.8	18.0	21.2	49.5
6	Goldsmith Oxidized	0 - 2	78.8	3.4	17.8	34.1
8	Alice Dump Lower Oxidized	0 - 6	62.8	18.0	19.2	27.7
9	Dump below Mt. Con	0 - 6	84.8	6.0	9.2	31.9
11	Silver Queen East End	0 - 4	85.0	10.0	5.0	70.1
13	Anselmo South End	0 - 4	85.0	6.0	9.0	41.6
14	Original Mine South End	0 - 4	72.8	14.0	13.2	38.2
18	Tom Gray Mine	0 - 4	62.8	14.0	23.2	56.2
21	Edna	0 - 4	66.8	14.0	19.2	64.1
22	Baltic	0 - 4	72.8	16.0	11.2	51.8
23	Colorado	0 - 4	54.8	18.0	27.2	47.1
BR-100*	Plutus	0 - 24	65.0	14.0	21.0	0.0
BR-103*	Little Sarah	0 - 24	67.0	16.0	17.0	0.0
BR-106*	Sankey	0 - 24	65.0	16.0	19.0	0.0
BR-108*	Nettie (No. 2)	0 - 24	69.0	15.0	16.0	0.0
BR-113A*	Travona	0 - 6	77.0	15.0	8.0	0.0
BR-113B*	Travona	0 - 24	74.0	13.0	13.0	0.0
BR-117*	Emma	0 - 12	63.0	23.0	14.0	0.0
BR-118*	Colorado	0 - 24	66.0	11.0	23.0	0.0
BR-143*	Butte-New England	0 - 24	55.0	22.0	23.0	0.0
BR-156*	Kelley	0 - 24	69.0	17.0	14.0	0.0
BR-158*	New Era 3 & 4	0 - 24	71.0	16.0	13.0	0.0
BR-179*	Mt. Con	0 - 24	72.0	14.0	14.0	0.0
BR-203A*	Alice	0 - 6	77.0	16.0	7.0	0.0
BR-203B*	Alice	0 - 24	76.0	13.0	11.0	0.0
BR-205*	Unnamed	0 - 24	80.0	11.0	9.0	0.0
CLTA-1*	Clark Tailings - Dark	0 - 24	31.0	59.0	10.0	0.0
CLTA-2*	Clark Tailings - Light	0 - 24	75.0	19.0	6.0	0.0

* Hydrometrics, 1983.

TABLE 7. SOIL CHEMICAL CHARACTERISTICS OF WASTE DUMP MATERIALS

Sample Number	pH	EC	Ca	Mg	Na	SO ₄	Cu	Fe	Mn	Zn
	-----mmhos/cm-----			-----mg/l-----						
1	7.9	0.2	33.9	8.0	5.1	1.9	0.1	0.1	0.1	0.1
2	7.0	0.2	16.0	4.3	2.8	2.0	0.1	0.1	0.1	0.1
3	8.5	0.1	143.6	46.3	4.0	28.9	0.1	0.1	0.5	0.1
6	3.0	0.6	695.0	26.4	3.0	1504.0	1.8	22.4	61.0	17.3
8	3.2	0.2	184.0	29.0	5.3	479.0	0.1	1.0	1.0	49.7
9	2.6	0.8	537.0	193.0	21.5	1142.0	95.7	446.0	95.3	645.1
→11	2.6	1.9	725.0	1565.0	250.2	6088.0	1902.0	9003.0	561.3	7137.5
13	2.3	1.3	1092.0	1271.0	97.7	3899.0	799.0	3838.0	659.8	1630.7
14	4.1	0.2	184.0	19.6	38.4	194.0	53.4	67.3	18.2	105.9
18	2.4	1.5	672.0	576.0	108.0	5114.0	443.6	3730.0	199.1	2480.0
21	2.7	1.4	714.0	1439.0	93.2	4581.0	1463.0	2884.0	782.0	1135.0
22	3.1	0.6	677.0	146.0	26.7	784.0	0.0	0.0	0.0	0.0
23	2.5	1.4	788.0	609.0	146.5	3570.0	0.0	0.0	0.0	0.0
BR-100	6.0	0.8	61.0	7.0	3.0	484.0	0.1	0.0	147.0	3
BR-103	6.2	0.5	30.0	6.0	2.0	263.0	0.1	0.0	93.0	0.5
BR-106	2.2	6.9	459.0	23.0	17.0	6880.0	7.1	0.0	242.0	20.9
BR-108	6.8	1.2	286.0	16.0	4.0	713.0	0.1	0.0	1.3	0.4
BR-113A	7.3	0.8	80.0	62.0	10.0	532.0	0.1	0.0	0.1	0.1
BR-117	2.5	5.0	775.0	154.0	1.0	3360.0	177.0	0.0	91.0	235.0
BR-118	2.6	3.9	531.0	71.0	63.0	3200.0	104.0	0.0	21.3	201.0
BR-143	2.8	10.4	507.0	618.0	1780.0	11300.0	1460.0	0.0	289.0	427.0
BR-156	2.7	4.0	770.0	91.0	2.0	2560.0	52.5	0.0	40.6	160.0
BR-158	2.8	1.6	34.0	23.0	30.0	1100.0	23.1	0.0	7.9	165.0
BR-179	2.8	3.1	669.0	80.0	27.0	2580.0	54.7	0.0	34.3	115.0
BR-203A	3.3	1.8	362.0	47.0	14.0	1490.0	2.9	0.0	128.0	33.3
BR-203B	3.1	2.8	639.0	81.0	21.0	2560.0	3.5	0.0	187.0	70.2
BR-205	6.6	0.5	139.0	23.0	15.0	228.0	0.1	0.0	0.1	0.1
CLTA-1	5.6	6.8	645.0	345.0	6.0	5360.0	0.7	0.0	2375.0	565.0
CLTA-2	2.4	5.7	762.0	42.0	1.0	4700.0	13.3	0.0	109.0	397.0

slope, lack of available water-holding capacity and low concentrations of plant nutrients. Use of non-acid materials to isolate or bury acid waste should be considered as a possible option in the reclamation plan.

✓ Tailings in the project area are confined to the Clark Tailings pond at the southwest edge of Butte. Historically, routing of surface water across the Clark Tailings has resulted in severe erosion and gullyng of the tailings. Flood control structures have been installed (Hydrometrics, 1983). Tailings differ from waste dump material in that they lack rock fragments and are composed of alternating layers of medium sand and clay and fine silt. The upper part of the Clark
✓ Tailings are finer-grained than the lower part reflecting a change in the milling method. The upper clayey dark-colored tailings a pH of 5.6, and EC of 6.8 and excessive levels of Zinc and Manganese. The lower light sandy tailings have pH of 2.4 and an EC of 5.7 with high copper, manganese and zinc. The stratified nature of the tailings makes them poorly drained and may prevent rooting.

CONTAMINATION HAZARD

Direct exposure to waste or tailings material can lead to excessive metal accumulation by humans, especially for metals such as lead which are accumulated in biological systems. At least three mechanisms of human uptake of metals have been identified including respiratory, dermal contact leading to unintentional ingestion and pika. Respiratory uptake of metals in fugitive dust is a problem even in off-

site areas and is discussed in detail in Appendix C. Entrainment of dump materials by wind is uncommon on the waste dumps due to the coarse texture, uneven surface, broken topography of the sites and formation of a crust. Tailings, however, are susceptible to direct entrainment by high winds. An important mechanism for entrainment of dump wastes involves deposition of wastes on city streets by runoff, subsequent drying of the material and generation of dust by vehicle traffic. Use of waste sites for recreational, dirt-bike or off-road vehicle use also exposes the public to chronic high levels of metals in the dust. Dermal contact has been found to be the primary mechanism of lead uptake by lead mill workers and their family members. Small amounts of dust carried on hands or clothing can be inadvertently consumed or respired. Dermal contact will occur in children playing on waste dumps or in adults using the site for motorcycle and off-road vehicle recreation. No studies of dermal contact with minor have been conducted for the Butte area. The final mechanism of metal uptake by direct contact is pika, or the intentional consumption of soil material by young children. The ingestion of metals also may occur by consumption of home garden crops. The EPA has identified home gardens as a primary source of metal accumulation by humans in contaminated areas.

Cadmium, lead and arsenic are elements of concern in waste materials in the Butte-Walkerville area. Cadmium is one of the most mobile metals and is toxic at low concentrations. Cadmium accumulation through the

food chain is of particular concern and food consumption from a contaminated home garden is the most likely contamination pathway.

Lead is most likely to be accumulated by ingestion and respiration and occurs in waste dumps in concentrations up to 1800 ppm (parts per million). Recreational use of waste dumps and the Clark Tailings will cause uptakes of metals.

Waste dumps and adjacent playground area should be reclaimed on a priority basis where health threats from air quality and direct exposure can be demonstrated or are likely. These sites are described in the section on public health hazards.

RECLAMATION CONSIDERATIONS

Substantial regrading will be required on most waste dumps to reduce erosion sufficiently to enable vegetation to become established on reclaimed dump surfaces. Slope grades should not exceed 20 percent on long slopes (>500 feet) or 25 to 30 percent on shorter slope lengths. At many sites, there will be insufficient space to extend slopes the required amount to adequately reduce dump slopes. On these dumps, a series of terraces should be constructed to collect runoff and convey it down a rock-lined channel or drop structure. A similar technique was used by the Anaconda Minerals Company at the Continental Dump East of Butte with considerable success.

The key to adequate reclamation of acid waste dumps is to provide an adequate depth of non-toxic cover material with sufficient water-holding capacity to be a viable plant root zone. The assumption underlying the cover soil depth recommendation is that a permanent vegetative cover is required to reduce erosion. Soil cover depth can be reduced by the incorporation of lime into the top 4 to 6 inches of the waste.

Based on a review of the literature and the laboratory examination of acid waste dump materials and tailings in the Butte-Walkerville study area, 24-inches of cover soil would be required to provide an adequate root zone depth. Cover soil depth could be reduced to 18 inches if 15 tons per acre of lime were placed at the soil/spoil interface. Cover soil depth of 12 inches with 60 tons per acre of lime at the interface worked into the spoil 6 inches would also provide an adequate root zone. The cost of obtaining a suitable cover soil, delivered in Butte, plus liming costs (lime + tillage) will ultimately determine the cover soil thickness and lime application rate selected for use.

Use of locally available cover soil materials, including alluvium from the McQueen area, should be investigated to reduce soil costs. Soil should have a water-holding capacity of at least 1.5 inches per foot of soil depth (12.5 percent) and should rank as fair or good in quality. Poor quality cover soil can be used where the property causing the poor ranking is treated to improve its adverse effects. Cover soil materials should be tested for nutrient element content (N, P, K). It

is expected that available cover soil materials will be low in all these elements.

Neutral waste dumps are less toxic than acid dumps but may require reclamation. A cover soil depth of at least one foot probably is sufficient for the neutral dumps. Neutral dump materials could also be used to bury or isolate acid dump materials from the applied cover soil. If soil pH of the dump material is less than 5.5, then two tons of lime should be applied and incorporated to a six-inch depth before application of cover soil. Soil fertilizer requirements for the cover soiled neutral waste material would be the same as for soil covers over acid wastes.

Tailings require a different approach to reclamation than waste dump materials. Extensive regrading of the Clark Tailings is not necessary due to the generally flat configuration of these tailings. However, erosion by runoff through the middle of the tailings has left some steep slopes that will require regrading for stability.

If air quality is the only significant health threat from the Clark Tailings, then application of a surface treatment may be sufficient to reduce wind erosion of the tailings. The Anaconda Minerals Company has successfully used a thin veneer of 1/4 inch minus gravel on the Opportunity Ponds to reduce fugitive dust. The application of a gravel mulch will slightly decrease evaporation of precipitation and may

correspondingly increase the amount of precipitation infiltration into the tailings. Mulch thickness should, therefore, be minimized.

Revegetation of the tailings pond should reduce drainage to zero even in above average precipitation years. Cover soil application to the tailings would be required to allow revegetation of the tailings. Water movement observed in tailings is very slow which may cause perched water tables to form and allows acid materials to rise by capillary action to the soil surface. As a result, the cover soil depths and lime rates recommended for acid dumps should be increased by 50 percent for use on tailings. If a 6-inch gravel layer were placed between the cover soil and tailings as a capillary barrier (Barth and Martin, 1980), then the same soil depth and lime rates used for acid dumps would be suitable. Costs to revegetate the Clark Tailings would be very high.

VEGETATION

Vegetation in the Butte area has been characterized by Culwell (1977), ECON (1980), Montana Department of State Lands (1981), MERDI (1978), and Hydrometrics (1983). The most common vegetation type found on undeveloped areas is dominated by rubber rabbitbrush (Chrysothamnus nauseosus) in association with various graminoids including bluebunch wheatgrass (Agropyron spicatum) and bluegrasses (Poa spp.). Practically all the vegetation in Butte and on the surrounding hillsides had disappeared by 1890 as a result of air pollution from smelting and heap roasting (MacMillan, 1972). Existing vegetation in the area, therefore, represents an early successional stage developing since the demise of heap roasting and relocation of smelting to Anaconda. Species composition generally reflects this history with a paucity of desirable species and an abundance of invader species and less desirable forbs and grasses.

Vegetation at inactive mines and waste dumps in the Butte area was qualitatively inventoried during June and August, 1982 in conjunction with an inventory for Anaconda Minerals Company (Hydrometrics, 1983) and again in October, 1983 and March, 1984 (Table 8).

Most sites were essentially barren with vegetation restricted to depressions, areas protected from wind-blown material and areas around the perimeter of waste dumps. The general lack of vegetation on mine sites is attributable to steep slopes and poor physical and chemical

TABLE 8. PLANT SPECIES OCCURRING ON OR ADJACENT TO ABANDONED MINES IN THE BUTTE AREA

GRASSES AND GRASSLIKE PLANTS	MOUNTAIN					ALICE MINE AREA	EMMA MINE AREA	SOUTHWEST BUTTE AREA
	BELMONT AREA	CON/STEWART AREA	WALKERVILLE AREA	TRAVONA AREA				
AGROPYRON SPP.	X							
AGROPYRON CANINUM		X		X			X	X
AGROPYRON CRISTATUM								
AGROPYRON DASYSTACHYUM				X	X			
AGROPYRON REPENS								X
AGROPYRON SMITHII			X	X				
AGROPYRON SPICATUM				X	X			
AGROPYRON TRACHYCAULUM			X					
AGROSTIS ALBA								X
AGROSTIS SCABRA	X		X	X	X			X
ALOPECURUS GENICULATUS								X
BROMUS INERMIS	X			X				X
BROMUS TECTORUM								
CAREX DOUGLASII	X	X	X	X	X			X
CAREX ELEOCHARIS			X					X
CAREX LENTICULARIS								
CAREX NEBRASCENSIS				X	X			
DACTYLIS GLOMERATA								
DESCHAMPSIA CAESPITOSUS				X				X
ELEOCHARIS PALUSTRIS								X
ELYMUS CANADENSIS						X		X
ELYMUS CINEREUS								
FESTUCA IDAHOENSIS			X	X				
HORDEUM JURATUM	X	X	X	X			X	X
JUNCUS SPP.								
JUNCUS BALTICUS	X							X
KOELERIA CRISTATA			X				X	X
MUHLENBERGIA ASPERIFOLIA	X							
MUHLENBERGIA RICHARDSONIS	X							
ORYZOPSIS HYMENOIDES			X	X				
PHLEUM PRATENSE								
POA SPP.	X		X	X				
POA COMPRESSA		X	X	X			X	X

TABLE 8. PLANT SPECIES OCCURRING ON OR ADJACENT TO ABANDONED MINES IN THE RUTTE AREA (CONT.)

GRASSES AND CRASSLIKE PLANTS (CONT.)	BELMONT AREA	MOUNTAIN CON/STEWART AREA	WALKERVILLE AREA	TRAVONA AREA	ALICE MINE AREA	EMMA MINE AREA	SOUTHWEST RUTTE AREA
POA FENDLERIANA	X	X	X	X	X		X
POA PRATENSIS			X		X		X
POA SANDBERGII							
STIPA COMATA	X		X	X			X
STIPA OCCIDENTALIS VAR. OCCIDENTALIS			X				X
STIPA VIRIDULA	X		X				X
<u>FORBS</u>							
ACHILLEA MILLIFOLIUM	X	X	X	X	X		X
ALYSSUM SPP.					X		
ANTENNARIA MICROPHYLLA			X				
ARABIS SPP.	X		X	X	X		X
ARTEMISIA LUDOVICIANA	X		X	X	X		X
ASTER SPP.			X				
ASTER CHILENSIS	X						X
ASTER LAEVIS	X	X			X	X	X
ASTRAGALUS SPP.							
ASTRAGALUS CANADENSIS							X
CAMELINA MICROCARPA	X			X			
CAMPANULA SPP.		X					
CAPSELLA BURSA - PASTORIS	X		X				X
CATABROSA AQUATICA	X		X				X
CENTAUREA MACULOSA	X	X	X	X	X	X	X
CHAENACTIS DOUGLASII		X	X		X		X
CHENOPODIUM ALBUM	X				X	X	X
CIRSIIUM ARVENSE	X			X	X	X	
CIRSIIUM UNDULATUM							X
CLEOME SERRULATA			X				X
COMANDRA UMBELLATUM	X						X
CRYPTANTHA INTERRUPTA			X				
DESCURAINIA PINNATA	X	X		X		X	X
DRAEA SPP.	X						
EPILOBIUM GLANDULOSUM							X
ERICERON COMPOSITUS					X		X
ERIOCONUM SPP.	X				X		X

TABLE 8. PLANT SPECIES OCCURRING ON OR ADJACENT TO ABANDONED MINES IN THE BUTTE AREA (CONT.)

FORBS (CONT.)	BELMONT AREA	MOUNTAIN CON/STEWART AREA	WALKERVILLE AREA	TRAVONA AREA	ALICE MINE AREA	EMMA MINE AREA	SOUTHWEST BUTTE AREA
ERIOGONUM UMBELLATUM			X				X
ERYSIMUM INCONSPICUUM		X					
GLADIOLAS SPP.							
GRINDELIA SQUARROSA	X			X		X	X
GYPSOPHILA PANICULATA	X	X	X	X			X
HETEROTHECA VILLOSA	X		X		X		X
HUMULUS LUPULUS		X					
IRIS MISSOURIENSIS							X
KOCHIA SCOPARIA	X					X	X
LACTUCA SERRIOLA		X					
LEPIDIDIUM DENSIFLORUM			X		X		X
LEPIDIDIUM PERFOOLIATUM	X	X		X		X	X
LINARIA DALMATICA	X	X	X				
LINARIA VULGARIS	X	X			X		X
LITHOSPERMUM RUDERALE			X				X
LUPINUS SPP.							
LUPINUS SERICEUS			X				X
LYCHNIS ALBA	X				X		
LYCIUM HALIMIFOLIUM		X					
MATRICARIA MATRICARIOIDES	X						X
MELILOTUS ALBA							
MELILOTUS OFFICINALIS	X						X
MENTZELIA LAEVICAULIS	X	X	X	X	X		X
MICROSERIS CUSPIDATA			X				
MONOLEPSIS NUTTALLIANA							X
OENOTHERA BIENNIS					X		
PENSTEMON SPP.				X			
PHACELIA HASTATA							
PHLOX SPP.	X	X	X		X		
PHLOX HOODII							X
PHLOX LONGIFOLIA							
POTENTILLA SPP.							X
RANUNCULUS CYMBALARIA	X			X			X

TABLE 8. PLANT SPECIES OCCURRING ON OR ADJACENT TO ABANDONED MINES IN THE BUTTE AREA (CONT.)

FORBS (CONT.)	BELMONT		MOUNTAIN		WALKERVILLE		TRAVONA		ALICE		EMMA MINE		SOUTHWEST	
	AREA	CON/STEWART	AREA	AREA	AREA	AREA	AREA	AREA	MINE AREA	AREA	AREA	AREA	ROUTE AREA	ROUTE AREA
RORIPPA NASTURTIUM - AQUATICUM													X	X
RUMEX SPP.	X												X	X
RUMEX ACETOSELLA													X	X
SALSOLA KALI	X		X				X						X	X
SENICIO SPP.	X													
SILENE SPP.														
SILENE SCOULERI													X	X
SISYMERIUM LOESLII											X		X	X
SOLANUM DULCAMARA													X	X
SOLIDAGO MISSOURIENSIS	X												X	X
TARAXACUM OFFICIANALE	X						X						X	X
TRAGOPOGON DURIUS														
TRIFOLIUM SPP.				X									X	X
VERASCUM THAPSUS	X						X			X				
<u>SURSHRUBS AND SHRUBS</u>														
ARTEMISIA ABSINTHIUM	X						X					X	X	X
ARTEMISIA FRIGIDA	X						X						X	X
ARTEMISIA TRIDENTATA							X							
ASTRIFLEX HORTENSIS														
CHRYSOETHAMNUS NAUSEOSUS				X			X			X		X	X	X
CHRYSOETHAMNUS														
VISCIDIFLORUS										X			X	
JUNIPERUS COMMUNIS														
RIBES SPP.													X	X
ROSA SPP.										X			X	X
SALIX SPP.														
SALIX EXIGUA										X				
SALIX MYRTILLIFOLIA														
SPIRAEA SPP.														
XANTHOCEPALUM SAROTHRAE				X										

TABLE 8. PLANT SPECIES OCCURRING ON OR ADJACENT TO ABANDONED MINES IN THE BUTTE AREA (CONT.)

TREES	MOUNTAIN						
	BELMONT AREA	CON/STEWARD AREA	WALKERVILLE AREA	TRAVONA AREA	ALICE MINE AREA	EMMA MINE AREA	SOUTHWEST BUTTE AREA
JUNIPERUS SCOPULORUM			X				X
PINUS CONTORTA			X				
POPULUS TREMULOIDES							X
POPULUS TRICHOCARPA			X				
PSEUDOTSUGA MENZIESII							X
SORBUS SCOPULINA				X			

EACH AREA INCLUDES THE FOLLOWING MINES:

BELMONT AREA: OTISCO, HOY, HESPERUS, COLORADO, BELMONT, RAMSDEL AND MARY LOUISE.
 MT. CON/STEWARD AREA: LITTLE MINA, CLEAR GRIT, ORIGINAL NO. 6, ORIGINAL, BENHAM, MOUNTAIN CON, PARROT, BUFFALO AND STEWARD.
 WALKERVILLE AREA: RISING STAR, GOLDSMITH, EVELINE, VENUS, MOOSE, MACNA CHARTA, VALDENHERE, MISSOULA, CORRA, DIAMOND AND LEXINGTON.
 TRAVONA AREA: TRAVONA, STAR WEST, BRITANIA, TZAKERA, BONANZA, RANNISTER AND OPHIR.
 ALICE MINE AREA: ALICE, PAYMASTER, AND BELLE OF BUTTE.
 EMMA MINE AREA: EMMA, ANSELMO, WEST CAGNON, MARQUI, YELLOW JACKET AND SYNDICATE.
 SOUTHWEST BUTTE AREA: ARDSLEY, BUTTE AND DATA FROM CLARK AND COLORADO TAILINGS AREAS.

properties of the waste dumps. Vegetation adjacent to most dump sites was dominated by rubber rabbitbrush (Chrysothamnus nauseosus), dry-site grasses and sedges and numerous undesirable forbs.

Table 9 lists percent vegetative cover, adjacent land use and dominant plant species occurring on mine sites where revegetation is a potential reclamation option. The majority of the sites are located in an urban area. Sites in the Walkerville area and southwest of Butte are found within disturbed rangeland.

TABLE 9. VEGETATIVE COVER, ADJACENT LAND USE AND DOMINANT PLANT SPECIES ON ABANDONED MINES IN THE BUTTE AREA

<u>Mine</u>	<u>Percent Vegetative Cover</u>	<u>Adjacent Land Use*</u>	<u>Dominant Vegetation on Waste Dumps**</u>
<u>Belmont Area</u>			
Otisco (air)	0	U (I)	B
Hoy	1	U	Cema
Hesperius (area)	1	U	Cema, Kosc, Poa spp., Arab
<u>Mountain Con-Stewart Area</u>			
Little Mina	0	U	B
Clear Grit	1-5	U	Poa spp., Cema, Phha
Original No. 6	1	U	Cema, Kosc, Poa spp.
Benham	1	U	Kosc, Cema
<u>Walkerville Area</u>			
Rising Star (Lessee No. 1)	1	DR	Chna, Stco, Brte, Cema
Rising Star (Lessee Shaft)	1	DR	Chna, Cema
Rising Star (Main Shaft)	1	DR	Chna, Cema
Goldsmith (Tong)	1	DR	Chna, Veth, Cema, Brte
Paymaster	1	U	Poco, Elymus, Chna, Cema
Eveline	5	DR	Chna, Cema, Phha
Moose (Auraria)	1	DR	Cema
Magna Charta (351)	0-50	DR	Chna, Poa spp.
Valdemere	0-50	DR	Feov, Chna
Bell of Butte	5	U	Cema, Chna
<u>Miscellaneous</u>			
Mary Louise	50	U	Popr, Cema
Ardsley Butte	1-5	DR	Agsc, Orhy, Cema, Chna
Bonanza	25-30	U, DR	Cema, Saka, Poa spp.
Anselmo (air)	5	U	Cema, Populus, Poa spp.
Ophir	1-5	U	Cema, Chna, Agsm, Poa spp.
Britannia	1-20	DR	Cema, Saka, Chna, Orhy
Missoula (Ryan)	1-20	U, DR	Chna, Saka, Poa spp., Agsc, Cema

Table 9, continued

<u>Mine</u>	<u>Percent Vegetative Cover</u>	<u>Adjacent Land Use*</u>	<u>Dominant Vegetation on Waste Dumps**</u>
<u>Waste Dumps</u>			
Ophir	10	U	Cema, Chna, Agsm
Anselmo	1	U	Cema, Populus
Emma	1	U	Agca, Hoju, Juba, Poco, Chna, Arab
Original	5(0-25)	U	Cema, Chna, Agropyron spp.
Mountain Con	1	U(I)	Cema
Travonia/Star	0-50	U, DR	Chna, Cema, Agsc, Poa spp.
West Area			
Alice	2	U, DR	Cema, Chna, Agda, Meof, Brte, Agsc, Elca

* Adjacent land use: U = Urban
I = Industrial
DR = Disturbed Rangeland

** Vegetation Abbreviations:

Agca - Agropyron caninum
Agda - Agropyron dasystachynm
Agsc - Agrostis scabra
Agsm - Agropyron smithii
Arab - Artemisia absinthium
B - Barren
Brte - Bromus tectorum
Cema - Centaurea maculosa
Chna - Chysothamnus nauseosus
Elca - Elymus canadensis
Feov - Festuca ovina
Hoju - Hordeum jubatum
Juba - Juncus balticus
Kosc - Kochia scoparia
Meof - Melilotus officinalis
Orhy - Oryzopsis hymenoides
Phha - Phacelia hastata
Poco - Poa compressa
Popr - Poa pratensis
Saka - Salsola kafi
Stco - Stipa comata
Veth - Verbascum thapsus

SITE RANKING MATRIX

All abandoned mine sites in the Butte study area were ranked based on their existing and/or potential threat to human health and safety as well as on other environmental factors. An Environmental Parameter Matrix (Figure 3) was completed for each site to determine numerical values reflecting adverse site conditions (Table 10).

Table 10 presents two numerical values derived from completion of the Environmental Parameter Matrix (EPM) for each site.

Where: EPM Value = Sum of all weighted values

Adjusted EPM Value = EPM Value - 98¹

Features such as public visibility of the sites, proximity to major tourist attractions, property ownership, size of affected population and land use features are similar for all of the Butte abandoned mine sites. Based on these similar features, the value of 98 is common to each site when tabulating values derived from the EPM.

The EPM values are weighted most heavily to reflect hazards to human health and safety; therefore, ratings of sites using the EPM closely

¹ All mine sites in the Butte-Walkerville area have a number of features in common which result in a base score of 98 for all sites. To obtain a more realistic ranking spread, the base score of 98 was subtracted from each site. The new value is termed the adjusted EPM Value.

FIGURE 3. ENVIRONMENTAL PARAMETER MATRIX

Site Name: _____

PARAMETER	NONE	MINIMAL 1	MODERATE 2	EXTREME 3	A	B	FINAL
Human Life, Health & Safety	0 points No impact	1 point Potential Adverse Impact	2 points Potential Adverse Impact (Severe)	3 points Current Adverse Impact (Severe)	Parameter Score	Weighting Factor X 15	Final Score
Water Quality	No impact	Less than 1 mi. downstream impact	1-10 miles downstream impact	Greater than 10 mi. downstream impact		10	
Air Quality	No impact	Occasional fumes or fugitive dust.	Fugitive dust, Noxious odors, smoke, particulates	High levels pollutants		10	
Fish, Wildlife, and Plant Habitat	No adverse impact	Low impact	Moderate impact	High impact		5	
Aesthetics	No impact	Low Public value	Moderate Public value	High public value		2	
Public Visibility	Remote	>10 mi. to highway & town	1-10 mi. to highway & town	<1 mi. to highway & town		5	
Historic, Cultural & Recreational	No sites	Proximity to sites	Close proximity to sites	Major tourist sites in area		5	
Property Ownership		Private		Public		5	
Adjacent Land Use	Mining	Forest, Agriculture	Residential, commercial	Recreation (Parks, reservoirs)		4	
Affected Population	None	1-500 persons	500-2500 persons	Over 2500 persons		5	
ENVIRONMENTAL							
SOCIO-ECONOMIC							

FIGURE 3, continued
ENVIRONMENTAL PARAMETER MATRIX (continued)

PARAMETER	NONE	MINIMAL 1	MODERATE 2	EXTREME 3	A	B	FINAL
Potential Productivity of Affected Area	None	Forest	Pasture, Range	Cropland		4	
Productivity of Adjacent Area	None	Forest	Pasture, Range	Cropland		5	
Residential, Industrial, & commercial development	Low potential	Possible	Long range potential	High Potential		5	
Potential for Future Mining	High			Low		10	
Demonstration of Enhanced Reclamation Technology	Probability of Success	Low	Moderate	High		3	
Cost Effectiveness of Reclamation		Low	Moderate	High		8	
LAND USE UTILIZATION							

SOURCE: Skelly
& Loy, May 1979

COUNTY: _____

SITE NAME: _____

LOCATION: _____

QUAD MAP: _____

TOTAL FINAL SCORE: _____

TABLE 10. ABANDONED MINE RATINGS BASED ON ENVIRONMENTAL
PARAMETER MATRIX (EPM)

<u>Mine Site</u>	<u>EPM Value</u>	<u>Adjusted EPM Value</u>
<u>Walkerville Area</u>		
Alice Pit	167	69
West Gray Rock	148	50
351 Raise-Magna Charta	148	50
Rising Star	163	65
Moose	148	50
Goldsmith Group	148	50
Paymaster Lease	148	50
Venus	128	30
Eveline	148	50
Belle of Butte	128	30
Valdemere	148	50
Minnie Irvine	108	10
East Gray Rock	133	35
Corra	123	25
Diamond	113	15
<u>Mountain Con-Steward Area</u>		
Mountain Con	158	60
Steward	128	30
Parrott	148	50
Buffalo	158	60
Little Mina	158	60
Original #6	158	60
Benham	148	50
Bellona	98	0
Estella	118	20

Table 10, continued

<u>Mine Site</u>	<u>EPM Value</u>	<u>Adjusted EPM Value</u>
<u>Anselmo-Lexington Area</u>		
Lexington	167	69
Anselmo	162	64
Missoula (Ryan)	128	30
Syndicate Pit	167	69
Wappelo Area	148	50
Ravin	148	50
West Gagnon	148	50
Missoula #2	148	50
La Plata	118	20
Moscow	118	20
Silver King	113	15
Mount Moriah	108	10
New Era or Downey	118	20
Balmone	118	20
Oro Butte	118	20
<u>Belmont Area</u>		
Belmont	128	30
Colorado	173	75
Hesperus	148	50
Hoy	138	40
Otisco #2	128	30
Otisco	148	50
Ramsdell	133	35
Burns	98	0
Veronica	118	20
Syndicate	98	0
New England	118	20
Hickey	113	15
Anderson	118	20
Heany	108	10
Childe Harold #2	133	35

Table 10, continued

<u>Mine Site</u>	<u>EPM Value</u>	<u>Adjusted EPM Value</u>
<u>Other Areas</u>		
Travona	158	60
Emma	158	60
Ophir	158	60
Mary Louise	128	30
Ardsley Butte	163	65
Bonanza	128	30
Tecumseh	128	30
Britania	148	50
Star West	128	30
Tzarena	98	0
Henry	118	20
Clark Tailings	128	30

agree with ratings assigned to shafts and adits (see Appendix A). Determination of those sites which qualify for reclamation based on human health and safety risks was accomplished through use of the EPM, as well as through consideration of Safety and Health Hazard Factors.

OVERVIEW OF APPLICABLE RECLAMATION TECHNOLOGY

A number of reclamation options were examined for possible implementation at abandoned mine sites in the Butte - Walkerville area. Options examined include methodologies used by DSL at other abandoned mine sites in Montana and recent work by Office of Surface Mining (OSM) on shaft closures and by Hydrometrics (1983) on abandoned mines in Butte. Shaft backfilling, capping with reinforced concrete slabs or steel grates, plugging with concrete cones and site fencing have been discussed with DSL staff. The large diameter and great depth of some shafts, coupled with a demonstrated ability for extensive subsidence at the surface (small diameter, shallow shafts in Butte have subsided at the surface out to a diameter of 50 feet) makes backfilling, capping or plugging technically difficult and costly to implement. The closure of large diameter, very deep shafts with the likelihood of extensive surface subsidence apparently is a poorly developed technology in the United States.

Reclamation options can be separated into structural and non-structural measures. Structural measures would include fencing, shaft and adit closures, removal of hazardous facilities such as headframes in poor condition and construction of sediment traps. Non-structural measures would include site revegetation, recontouring, mulching and soil covering. Total site reclamation would typically include both structural and non-structural measures. However, non-structural

measures may not be needed to correct public health and safety problems at most sites.

STRUCTURAL MEASURES

Fencing provides a temporary and only partially effective method of controlling public access. Fencing has been used by the Anaconda Minerals Company in the Butte-Walkerville area with mixed results. Large sections of chain link fence have been removed from the perimeter of the Alice Pit and there is numerous evidence of persons going over or under fences at many sites. In addition, the condition of fencing deteriorates over time and periodic maintenance and replacement is required. Significant advantages of fencing are it does not preclude future reopening of the mine and it is less costly than other structural measures.

Backfilling is practical on adits and on shafts of total depth of about 1000 feet or less and where a source of fill is located nearby (Figures 4 and 5). Experience gained by former Anaconda Minerals Company staff suggests backfilling of deeper shafts is difficult to achieve because of bridging and subsequent failure of the backfill. For shallower shafts, manpower and equipment costs are low compared to other alternatives and backfilling does reduce the volume of waste material present at the surface. Because it is not possible to compact the backfill as it is placed, some future settling will occur and periodic refilling of the surface will be necessary. Therefore, structures should not be located on backfilled shafts. There is an abundance of

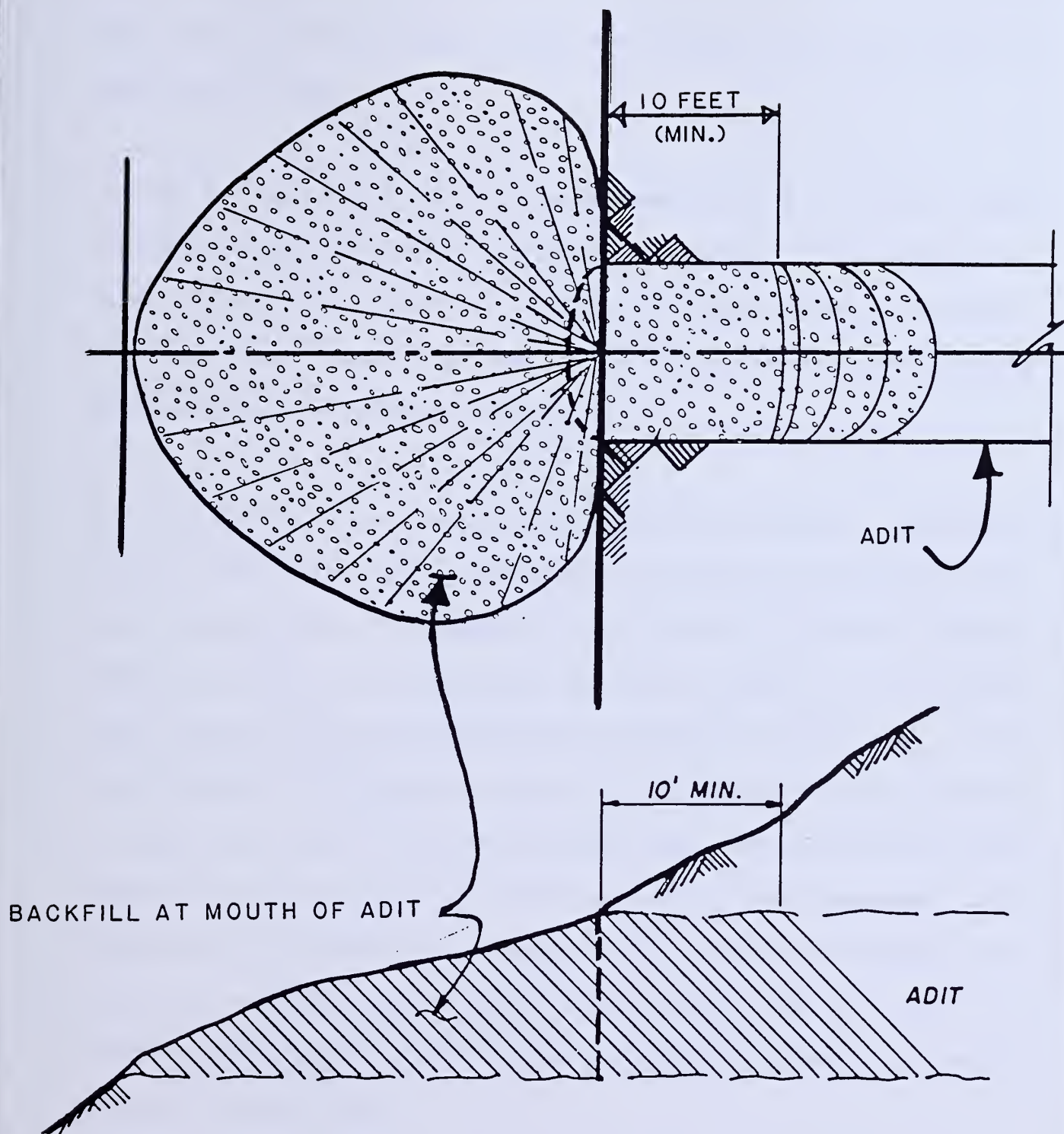


FIGURE 5

DETAIL FOR BACKFILLING MINE ADITS

waste dump material in the Butte-Walkerville area which can be used for shaft backfilling.

The DSL has used steel grates to cover mine openings at several remote locations where the cost of transporting concrete is not practicable. Steel, however, is expensive and may be subject to extensive corrosion from acidic earth materials. Removal of all or a portion of the grate would be needed to reopen the mine.

Recently the Office of Surface Mining (OSM) has begun using concrete filled, steel cones with an apex angle of 60 degrees to successfully plug vertical shafts in competent rock (Figure 6) The method requires fabrication of a steel cone which is braced internally to withstand loads imposed by handling and by the placement of wet concrete. The top of the shaft is shaped to accept the cone which is either lowered or tipped into place. The method permits shop fabrication and the cone tends to re-center itself if subsidence occurs after placement. The method can be quite costly, especially for large shafts, because the volume of concrete required for large shafts can be large. In addition, shaft plugging with a cone may preclude reopening and reusing the shaft in the future.

Reinforced concrete slabs require limited surface preparation and do not require specialized craftsmen to complete. They are cost-effective and permanent provided they are made sufficiently large to maintain an effective seal if shaft subsidence occurs. OSM notes that slabs

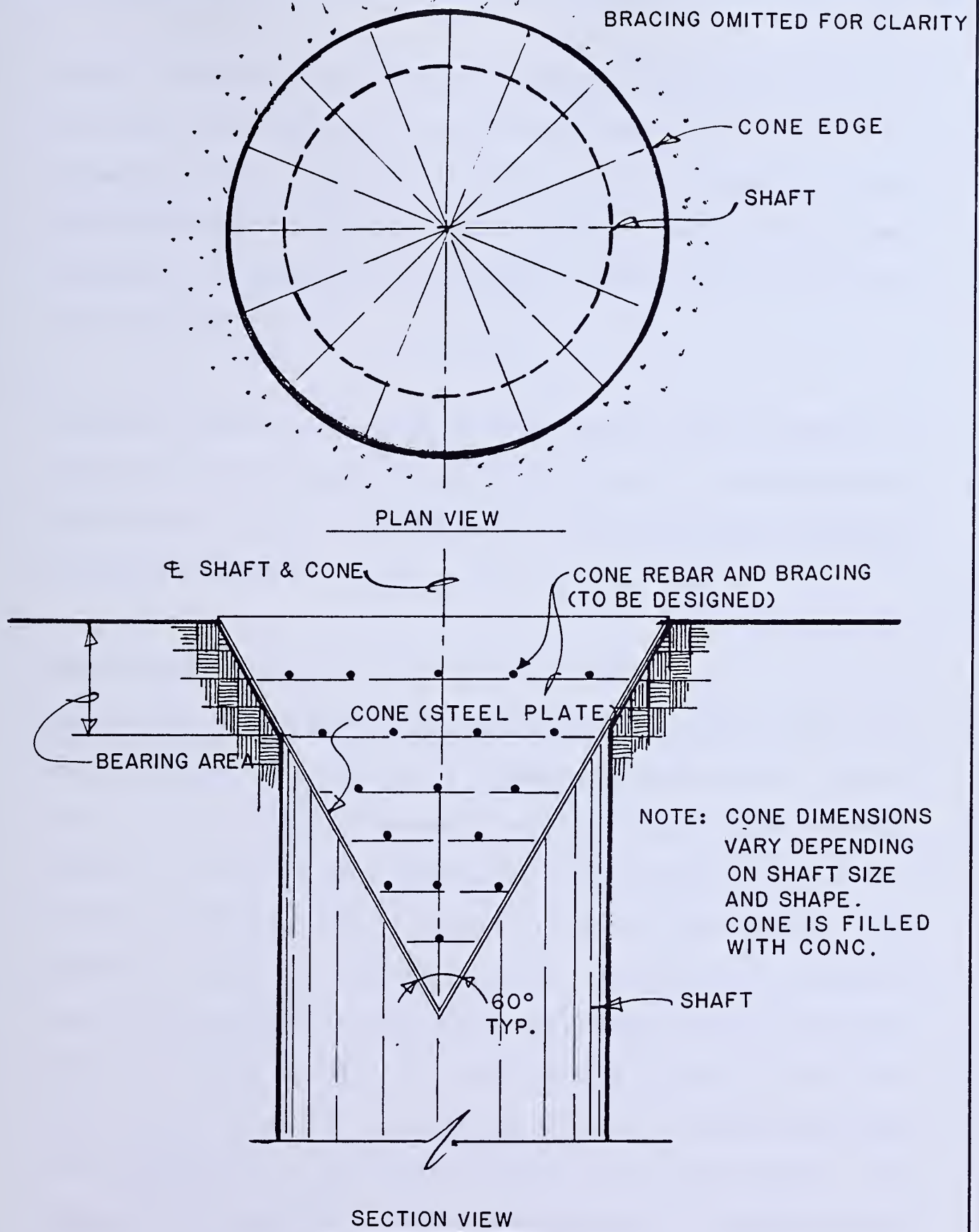


FIGURE 6

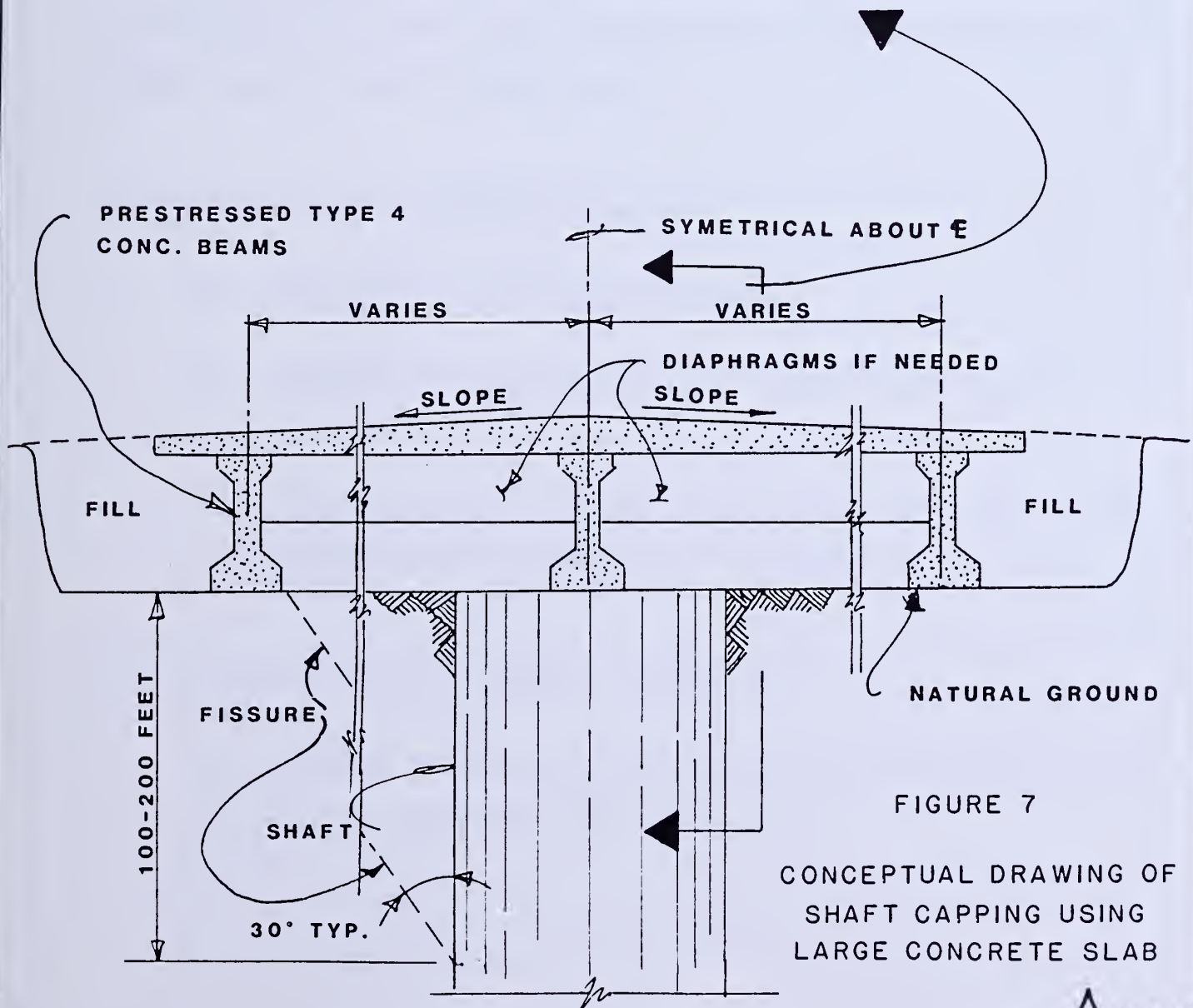
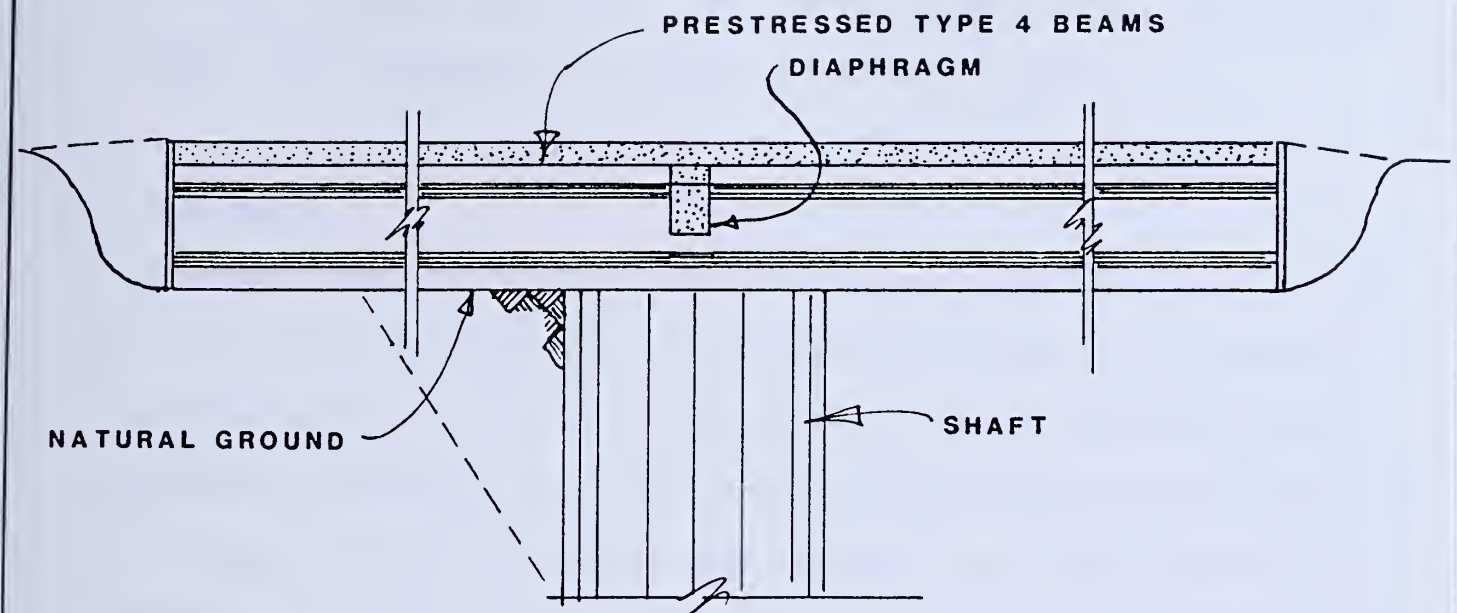
TYPICAL CONE INSTALLATION

slightly larger than the shaft are ineffective and must eventually be replaced as subsidence and surface water runoff erosion around the perimeter of the slab eventually results in the shaft reopening. Large slabs would need to be supported by concrete beams to ensure their integrity if subsidence occurred under a substantial portion of the slab (Figure 7).

Structural measures not related to shaft closure would be removal or replacement of failing waste dump retaining walls; construction of runoff control ditches, diversion berms and sediment traps; and removal of unsound structures.

NON-STRUCTURAL MEASURES

Numerous waste rock dumps, two open pits and a tailings pond area comprise extensive barren areas in Butte and Walkerville. Runoff erosion is the main environmental problem in most of these areas. However, air quality degradation also is of concern because runoff erosion carries significant volumes of waste dump material onto adjacent streets. This eroded material is pulverized by vehicle traffic and becomes susceptible to air entrainment and wind dispersal. Some sites such as the Clark Tailings are also susceptible to direct wind erosion. In addition, playgrounds with barren surfaces have also been constructed on or are located adjacent to some waste dumps. Site revegetation and mulching, combined with resloping or recontouring are non-structural measures which could be used on a site-by-site basis to



minimize erosion. Waste rock dump removal is only practical for small dumps with a disposal site, such as an open pit, nearby.

Rock Mulch

Crushed limestone applied in a thin veneer has been used on the Anaconda Minerals Company's tailings ponds near Anaconda, Montana to control wind erosion of tailings with considerable success (Marose, 1982 and Stephenson, 1984, pers. comm.). Crushed limestone obtained from a company quarry and crusher near Anaconda, and consisting of two-thirds by volume of 1/4-inch minus material and one-third by volume of size range of 1/4 inch to 3/4 inch material, is applied at the rate of about 15 cubic yards (23 tons) per acre.

Advantages of using a limestone cover are:

- 1) The option is relatively inexpensive.
- 2) Limestone has proven to be reliable for stabilization.
- 3) The application of limestone will add alkalinity to the tailings and would improve soil pH conditions.

Disadvantages of using a limestone veneer are:

- 1) Periodic reapplication may be required because of wind erosion, trafficking and runoff erosion.

- 2) It probably would be cheaper to use crushed aggregate or gravel supplied by a local contractor.
- 3) Machine application on steep slopes and confined sites may be difficult.

Gravel mulches recommended by the Forest Service are significantly different than limestone applications used by Anaconda Minerals Company staff on the Anaconda and Opportunity Ponds. Gravel mulches recommended by the Forest Service (1979) are applied at the rate of 235 tons/acre (approximately 1 inch thick) and consist of material with a diameter "...greater than 1/12 inch".

The application of a thick rock mulch could, however, decrease evaporation. Therefore, somewhat more water derived from precipitation may move downward through the tailings and waste rock than if surfaces were left uncovered. A thin rock mulch would not significantly decrease evaporation.

Mulching of waste dumps and the Clark Tailings would be more effective if steep embankments are first regraded to flatter slopes. Utilization of asphalt coatings and chemical dust suppressants is not recommended because of their relatively short life.

Revegetation

Potential revegetation alternatives are based on state-of-the-art technology which leave many questions unanswered. Research on use of

metal tolerant plants in the western United States is uncommon. The literature strongly indicates conventional revegetation following liming is unlikely to be successful. Therefore, conventional revegetation of waste dump materials and the Clark Tailings requires burying the material under a sufficiently thick layer of suitable soil. Revegetation of toxic waste is only totally solved by burying the material under a deep layer of non-toxic soil (Etherington, 1982).

Revegetation options are conventional revegetation and revegetation with genetically adapted species. Both revegetation options assume extensive regrading of existing steep embankments and deep erosion channels. If tailings and waste dumps are not removed. Conventional revegetation assumes the undesirable plant growth characteristics of the can be mitigated by removal or burial of the waste.

Alternatives considered for revegetation are:

- 1) Remove waste to a suitable disposal site and revegetate the original ground surface;
- 2) Revegetate with metal-tolerant plants; and
- 3) Covering the waste with a suitable soil and revegetating the surface.

Removal of Waste Dumps and the Clark Tailings

The total volume of material in waste dumps associated with the

abandoned mines in the vicinity of Butte is estimated to be ten million cubic yards. The Clark Tailings contains about one million cubic yards. Removal of waste dumps and the Clark Tailings would be very expensive and is economically unfeasible. In addition, a suitable disposal site or sites would have to be obtained.

Removal of waste dumps in many instances would result in the loss of what are often the only flat surfaces in the vicinity. Loss of these surfaces may be important within the city of Butte where some of the sites are already being used for parking lots and recreation. For some waste dumps, removal and disposal in adjacent or nearby pits would be possible. This is particularly true for dumps near the Alice Pit and the Syndicate Pit.

Hauling of waste dumps to disposal sites with large dump trucks probably would cause local traffic problems, road wear and transient air quality problems. However, removal of the dumps and subsequent revegetation of the underlying surface after suitable soil preparation would reduce sediment loading to adjacent streets, playgrounds and the municipal storm sewer system. It is impractical to remove all of the waste dumps.

Revegetate with Metal-Tolerant Plants

The alternative of using metal tolerant plants to revegetate mining wastes in Montana has been reviewed by Hydrometrics (1983) and Culwell (1983). Research in progress by Montana State University in

cooperation with Anaconda Minerals Company is evaluating the applicability of metal-tolerant plants for reclamation of the tailings ponds at Opportunity, Montana (Surbrugg, 1982). To date, however, there is very little data on the successful use of metal-tolerant plants for reclamation in the Northern Rocky Mountains. There are currently no commercial seed sources for these plants adapted to the Butte area. If the use of metal-tolerant plants becomes a viable revegetation option, reclamation costs may be substantially reduced on AML sites as liming and/or cover soil application may be unnecessary at some sites. However, current research suggests revegetation using metal-tolerant plants is unlikely to succeed on the Clark Tailings and on acid waste dumps.

Conventional Revegetation

Conventional revegetation implies that waste dumps have been removed, graded to reduce steep slopes, manipulated by gouging or terracing and limed prior to the application of a cover soil.

As discussed in the Soils section, the thickness of soil cover is dependent on both soil cover and lime costs, delivered in Butte, and varies from a thickness of 24-inches with no lime applied to a thickness of 12 inches if 60 tons/acre of lime were incorporated into the upper 6-inches of the waste material.

Soil samples from waste dumps showed nitrogen and phosphorous were very deficient at these sites and potassium was present in variable amounts.

Site by site nutrient analysis of waste dumps can be performed or, more practically, fertilizer application can be based on the assumption of no plant available nutrients.

An area north and east of Walkerville in the vicinity of Moose mines was revegetated during May 1982 (r. Gordon, pers. comm., 1983). Limited surface soils were spread over the graded area, fertilizer was applied at 300 pounds/acre of 16-20-0 and the area was harrowed and seeded with a Brillion seeder with the following mixture:

Species	Rate (Pounds/Acre)
Tall fescue	4
Crested wheatgrass	7
Western wheatgrass	4
Slender wheatgrass (Revenue)	10
Hard fescue (Durar)	2
Sheep fescue (Covar)	6
Canada bluegrass (Reubens)	4
Alfalfa (Ladak)	2
	39

The area was observed during October 1983. Established vegetation appeared stunted but was fairly effective in controlling erosion. Crested wheatgrass, hard or sheep fescue, slender wheatgrass and Canada bluegrass were the most conspicuous species.

Plant species selected for revegetating Butte AML sites is based upon the vegetation reconnaissance, the Plant Information Network data for Silver Bow County and a literature review. Information pertaining to

seed establishment potential, preferred species and seeding rates was derived from Long (1981), USBM (1974), Young (pers. comm., 1982), Bradshaw and Chadwick (1980) and Weisner (pers. comm., 1982). Species availability, seed purity and germination rates were supplied by seed producers. Specific recommendations concerning site preparation, fertilization, mulching and planting methods are discussed in detail in Appendix G.

RECLAMATION OPTIONS

Site specific reclamation plan alternatives have been developed for all Butte AML sites where clear threats to public health or safety have been identified. Those shafts with a safety hazard rating of 3 or greater (see Appendix A) were considered for corrective action (Table 11). Public health is a concern at nine waste dumps, three baseball fields and the Clark Tailings (Table 12). Erosion stabilization is recommended at these waste dumps and the Clark Tailings. Placement of a soil cover is recommended for the ball fields. Recommended options may be influenced by site-specific reviews with DSL staff, the Technical Advisory Committee and mine owners. Costs for revegetation of waste dumps and the Clark Tailings are very high and may not be economically feasible. Similarly, the technology of permanent structural closure of large, deep shafts is not well developed and will be costly. Partial backfilling of the Alice and Syndicate Pits also will be very costly and it may be more practical to repair existing fences. Filling of small, shallow shafts and the placement of a soil cover on ball fields can be achieved at reasonable cost and are recommended. Costs are summarized in Table 13. Detailed cost computations are in Appendix H.

SAFETY HAZARD

Forty-two safety hazards are identified in the Butte area. All are mine shafts with the exception of one shallow adit and the two open pits. Included in this list is a number of small shafts on which there

TABLE 11. RECLAMATION ALTERNATIVES FOR BUTTE AREA INACTIVE MINE SHAFTS

SITE	DEPTH (FT)	RECOMMENDED RECLAMATION OPTION	ESTIMATED AREA TO BE DISTURBED (ACRES)	HAUL DISTANCE (FT)	ESTIMATED VOLUME OF BACKFILL	ESTIMATED VOL. OF DUMP TO BE USED FOR	CONFIRMATION OF DEPTH REQUIRED	TEST REQUIRED
BELMONT AREA								
BELMONT	4300	CAP	1/2	N/A	N/A	N/A	NO	NONE
OTISCO (MAIN)	1000	BACKFILL	1	100	5000	25000-35000	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED.
OTISCO (AIR)	100 EST	BACKFILL	1	100	575 +	25000-35000	YES	NONE
COLORADO	2800	CAP	1	100	N/A	N/A	NO	NONE
HOY	200 EST	BACKFILL	1	50	1000	1000	YES	EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED.
HESPERUS	500 EST	BACKFILL	2	100	2500	2500-3500	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED.
HESPERUS AREA (UNNAMED)	UNKNOWN	BACKFILL	1	150	UNKNOWN	2500-3500	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED.
MT. CON - STEWARD AREA								
PARROTT (AIR)	2800	CAP	1/2	N/A	N/A	N/A	NO	NONE
ORIGINAL	3900	CAP	1/2 (1)	N/A	N/A	N/A	NO	NONE
MT. CON	5200	CAP	1/2 (1)	N/A	N/A	N/A	NO	NONE
LITTLE MINA	1200	BACKFILL	2	100	6000	15000-25000	YES	EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED.
BUFFALO	2200	CAP	1/2	N/A	N/A	N/A	NO	NONE
ORIGINAL #6	550	BACKFILL	1	50	2800	4500-6500	YES	EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED.
BENHAM	300 EST	BACKFILL	1	50	1500	2000-3000	YES	EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED.

(1) DOES NOT INCLUDE AREAS TO BE RECLAIMED FOR PUBLIC HEALTH HAZARDS.

TABLE 11 (CONT.)

SITE	DEPTH (FT)	RECOMMENDED RECLAMATION OPTION	ESTIMATED AREA TO BE DISTURBED (ACRES)	HAUL DISTANCE (FT)	ESTIMATED VOLUME OF BACKFILL	ESTIMATED VOL. OF DUMP TO BE USED FOR		CONFIRMATION OF DEPTH REQUIRED	TEST REQUIRED
						BACKFILL	BACKFILL (CU. YD.)		
MT. CON - STEWARD AREA (CONT.)									
STEWARD	4400	CAP	1/2	N/A	N/A	N/A	N/A	NO	NONE
CLEAR GRIT	600	BACKFILL	2	100	3000			YES	REMOVE STEEL HOUSING
ANSELMO - LEXINGTON AREA									
LEXINGTON	3200	CAP	1	N/A	N/A	N/A	N/A	NO	NONE
ANSELMO	4500	CAP	1/2 (1)	N/A	N/A	N/A	N/A	NO	NONE
MARQUIS	300	BACKFILL	1/2	50	1500		50000	YES	REMOVE STEEL HOUSING
WEST GAGNON	2800	CAP	1/2	N/A	N/A	N/A	N/A	NO	NONE
MISSOULA (RYAN)	500	BACKFILL	1	200	2500		4000-5000	YES	REMOVE EXISTING CONCRETE CAP
MISSOULA #2	100 EST	BACKFILL	1	500	500		UNKNOWN	YES	OPEN - REMOVE EXISTING COLLAR
RAVIN	1700	CAP	1/2	N/A	N/A	N/A	N/A	NO	NONE
WALKERVILLE AREA									
RISING STAR #1	500E	BACKFILL	2	100	2500		2500-3500	YES	EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED
RISING STAR (LESSEE)	150 EST	BACKFILL	2	300	750		USE RISING STAR MAIN DUMP	YES	EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED
RISING STAR (MAIN)	800	BACKFILL	2	150	4000		5000-7000	YES	EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED
GOLDSMITH (TONG)	800	BACKFILL	2	200	4000		10000-15000	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED
GOLDSMITH NONCONSOLIDATED	200 EST	BACKFILL	1	200	1000		10000-15000	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED

(1) DOES NOT INCLUDE AREAS TO BE RECLAIMED FOR PUBLIC HEALTH HAZARDS.

TABLE 11 (CONT.)

SITE	DEPTH (FT)	RECOMMENDED RECLAMATION OPTION	ESTIMATED AREA TO BE DISTURBED (ACRES)	HAUL DISTANCE (FT)	ESTIMATED VOLUME OF BACKFILL	ESTIMATED VOL. OF DUMP TO BE USED FOR BACKFILL (CU. YD.)	CONFIRMATION OF DEPTH REQUIRED	TEST REQUIRED
WALKERVILLE AREA (CONT.)								
PAYMASTER (LEASE)	300	BACKFILL	2	100	1500	2000-3000	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED
VENUS	200E	BACKFILL	1	500	1000	USE EVELINE DUMP	YES	EXCAVATE TO DETERMINE IF SHAFT ALREADY FILLED
EVELINE	700	BACKFILL	2	50	3500	5000-7000	NO	NONE
MOOSE	3800	CAP	1/2	N/A	N/A	N/A	NO	NONE
MOOSE (AURORIA)	250 EST	BACKFILL	1	50	1250	2000-3000	YES	EXCAVATE TO DETERMINE IF SHAFT ALREADY FILLED
DIAMOND		CAP	1/2	N/A	N/A	N/A	NO	NONE
351 RAISE-MAGNA CHARTA	300	BACKFILL	1/2	400	1500	1500-2500	YES	OPEN - REMOVE STEEL HOUSING
WEST GRAY ROCK	1800	CAP	1/2	N/A	N/A	N/A	NO	NONE
VALDEMINE	ADIT	BACKFILL	1	100	200	2000-4000	YES	EXCAVATE TO ADIT
BELLE OF BUTTE	500	BACKFILL	2	50	2500	3000-4000	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED
CORRA	2800	CAP	1/2	N/A	N/A	N/A	YES	DRILL TO DETERMINE IF SHAFT ALREADY FILLED
MISCELLANEOUS AREAS								
MARY LOUISE	500	CAP	1/2	N/A	N/A	N/A	NO	NONE
ARDSLEY BUTTE	360	FENCE ONLY	N/A	N/A	N/A	N/A	NO	
BONANZA	1000	BACKFILL	1	150	5000	6000-10000	YES	OPEN - REMOVE COVER

(1) DOES NOT INCLUDE AREAS TO BE RECLAIMED FOR PUBLIC HEALTH HAZARDS.

TABLE 11 (CONT.)

SITE	DEPTH (FT)	RECOMMENDED RECLAMATION OPTION	ESTIMATED AREA TO BE DISTURBED (ACRES)	HAUL DISTANCE (FT)	ESTIMATED VOLUME OF BACKFILL	ESTIMATED VOL. OF DUMP TO BE USED FOR BACKFILL (CU. YD.)	CONFIRMATION OF DEPTH		TEST REQUIRED
							REQUIRED	REQUIRED	
MISCELLANEOUS AREAS (CONT.)									
ANSELMO AIR	500	BACKFILL	1/2	1/4 TO 1/2 MILE	2500	USE ANSELMO DUMP	NO		OPEN - REMOVE COLLAR
TRAVONA	1500	CAP	1/2 (1)	N/A	N/A	N/A	NO		NONE
OPHIR	1000	BACKFILL	1 (1)	150	5000	5000-7000	NO		OPEN - REMOVE STEEL HOUSING
ENNA	1700	CAP	1/2 (1)	N/A	N/A	N/A	NO		NONE
BRITANIA	400	BACKFILL	2	200	2000	4000-6000	YES		EXCAVATE AT SURFACE TO DETERMINE IF SHAFT ALREADY FILLED

(1) DOES NOT INCLUDE AREAS TO BE RECLAIMED FOR PUBLIC HEALTH HAZARDS.

TABLE 12. RECLAMATION ALTERNATIVES FOR BUTTE AREA WASTE DUMPS, PLAYGROUNDS AND THE CLARK TAILINGS

<u>Site</u>	<u>Estimated Area to be Reclaimed (acres)</u>	<u>Recommended Reclamation Measures</u>
Anselmo	5 - 8	Minimal regrading to improve drainage; construct asphalt curb drain at dump crests.
Original	3 - 4	Minimal regrading to improve drainage; construct asphalt curb drain at dump crests.
Mt. Con	4 - 8	Minimal regrading to improve drainage; construct asphalt curb drain at dump crests.
Emma	2	Cover area with topsoil and revegetate.
Travona	5 - 7	Minimal regrading to improve drainage; construct asphalt curb drain at dump crests.
Ophir	2	Minimal regrading to improve drainage; construct asphalt curb drain at dump crests.
Colorado	3	Minimal regrading to improve drainage; construct asphalt curb drain at dump crests.
Little Mina	1	Minimal regrading to improve drainage; construct asphalt curb drain at dump rests.
Buffalo	1	Minimal regrading to improve drainage; construct asphalt curb drain at dump rests.
Baseball Field near Anselmo	1.6	Cover with 12" of suitable topsoil.
Baseball Field on Missoula Avenue	2.1	Cover with 12" of suitable topsoil.
Playground south of Alice Pit	1.8	Cover with 12" of suitable topsoil.
Clark Tailings	62	Cover with rock mulch.

TABLE 13. COST SUMMARY OF RECLAMATION OPTIONS

<u>SITE</u>	<u>DEPTH (FT)</u>	<u>RECOMMENDED RECLAMATION OPTION</u>	<u>ESTIMATED COST</u>
<u>BELMONT AREA</u>			
BELMONT	4300	CAP	\$96500
OTISCO (MAIN)	1000	BACKFILL	\$4750
OTISCO (AIR)	100 EST	BACKFILL	\$375
COLORADO	2800	CAP & IMPROVE DRAINAGE	\$99375
HDY	200 EST	BACKFILL	\$1450
HESPERUS	500 EST	BACKFILL	\$2875
HESPERUS AREA (UNNAMED)	UNKNOWN	BACKFILL	\$1375
<u>MT. CON - STEWARD AREA</u>			
PARROTT (AIR)	2800	CAP	\$95875
ORIGINAL	3900	CAP & IMPROVE DRAINAGE	\$102500
MT. CON	5200	CAP & IMPROVE DRAINAGE	\$119000
LITTLE MINA	1200	BACKFILL & IMPROVE DRAINAGE	\$9625
BUFFALO	2200	CAP & IMPROVE DRAINAGE	\$98000
ORIGINAL #6	550	BACKFILL & IMPROVE DRAINAGE	\$2065
BENHAM	300 EST	BACKFILL	\$1625
		SUB-TOTAL	\$635390

TABLE 13. (CONT.)

<u>SITE</u>	<u>DEPTH (FT)</u>	<u>RECOMMENDED RECLAMATION OPTION</u>	<u>ESTIMATED (ACRES)</u>
<u>MT. COM - STEWARD AREA (CONT.)</u>			
STEWARD	4400	CAP	\$96000
CLEAR GRIT	600	BACKFILL	\$2250
<u>ANSELMO - LEXINGTON AREA</u>			
LEXINGTON	3200	CAP	\$96000
ANSELMO	4500	CAP & IMPROVE DRAINAGE	\$109375
MARQUIS	300	BACKFILL	\$1125
WEST GAGNON	2800	CAP	\$94000
MISSOULA (RYAN)	500	BACKFILL	\$1875
MISSOULA #2	100 EST	BACKFILL	\$375
RAVIN	1700	CAP	\$94000
<u>WALKERVILLE AREA</u>			
RISING STAR #1	500E	BACKFILL	\$2375
RISING STAR (LESSEE)	150E	BACKFILL	\$1065
RISING STAR (MAIN)	800	BACKFILL	\$3500
GOLDSMITH (TONG)	800	BACKFILL	\$4000
GOLDSMITH NONCONSOLIDATED	300	BACKFILL	\$2125
		SUB-TOTAL	\$508065

TABLE 13. (CONT.)

<u>SITE</u>	<u>DEPTH (FT)</u>	<u>RECOMMENDED RECLAMATION OPTION</u>	<u>ESTIMATED COST</u>
<u>WALKERVILLE AREA (CONT.)</u>			
PAYMASTER (LEASE)	300	BACKFILL	\$2125
VENUS	200 EST	BACKFILL	\$2875
EVELINE	700	BACKFILL	\$3125
MOOSE	3800	CAP	\$94000
MOOSE (AURORIA)	250E	BACKFILL	\$1440
DIAMOND		CAP	\$96000
351 RAISE-MAGNA CHARTA	300	BACKFILL	\$1125
WEST GRAY ROCK	1800	CAP	\$95500
VALDEMINE	ADIT	BACKFILL	\$375
BELLE OF BUTTE	500	BACKFILL	\$6000
CORRA	2800	CAP	\$95000
<u>MISCELLANEOUS AREAS</u>			
MARY LOUISE	500	CAP	\$94000
ARDSLEY BUTTE	360	FENCE ONLY	\$6000
BONANZA	1000	BACKFILL	\$3750
		SUB-TOTAL	\$501315

TABLE 13. (CONT.)

<u>SITE</u>	<u>DEPTH (FT)</u>	<u>RECOMMENDED RECLAMATION OPTION</u>	<u>ESTIMATED COST</u>
<u>MISCELLANEOUS AREAS (CONT.)</u>			
ANSELMO AIR	500	BACKFILL	\$8000
TRAVONA	1500	CAP	\$109500
OPHIR	1000	BACKFILL	\$6750
EMMA	1700	CAP	\$122750
BRITANIA	400	BACKFILL	\$2000
<u>CLARK TAILINGS</u>			\$17500
<u>PLAYGROUNDS</u>			
BASEBALL FIELD NEAR ANSELMO		COVER WITH 12" SUITABLE SOIL	\$9750
BASEBALL FIELD ON MISSOULA AVE		COVER WITH 12" SUITABLE SOIL	\$12750
PLAYGROUND SOUTH OF ALICE PIT		COVER WITH 12" SUITABLE SOIL	\$10875
<u>OPEN PITS</u>			
ALICE PIT		FENCE PIT PERIMETER	\$60000
SYNDICATE PIT		REPAIR PIT PERIMETER FENCE	\$15000
		SUB-TOTAL	\$374875
		GRAND TOTAL	\$2019645

is little historic record. The depth and condition of these shafts must be determined before the need to backfill the shafts can be established. It is unknown whether these shafts have previously been backfilled or only bulkheaded near the surface. Table 14 lists the shafts for which more information is required. Two methods are available to determine shaft condition. If bulkheading or caving appears to be near the surface, a backhoe or crawler tractor can be used to excavate and expose the shaft. If the shaft is blocked or bulkheaded at a deeper level, a rotary drill rig must be used to drill a sloped hole 30 to 40 feet below the surface. If excavation or drilling exposes an open shaft below the bulkhead, then future subsidence is likely to occur. If the shaft is filled, no hazardous subsidence will appear and no reclamation action is required. However, slumping may continue on the surface.

Four methods of reducing the safety hazard of shafts were considered:

- 1) Backfill shaft with waste material;
- 2) Cover the shaft collar with a steel grate which extends to the perimeter of anticipated subsidence.
- 3) Place a sufficiently large concrete and steel cone in the shaft at or near the surface which extends to the perimeter of anticipated subsidence, and

TABLE 14. SHAFTS REQUIRING ADDITIONAL TESTING
BEFORE FURTHER RECLAMATION

<u>Site</u>	<u>Method Used to Determine Conditions</u>
Otisco (Main)	Drilling
Hoy	Dozer
Hesperus	Drilling
Hesperus (unnamed)	Drilling
Little Mina	Dozer
Benham	Dozer
Rising Star No. 1	Dozer
Rising Star (Lessee)	Dozer
Rising Star (Main)	Dozer
Goldsmith (Tong)	Drilling
Goldsmith (Nonconsolidated)	Drilling
Paymaster (Lease)	Drilling
Venus	Dozer
Moose (Auraria)	Dozer
Belle of Butte	Drilling
Corra	Drilling
Britania	Drilling
Eveline	Dozer

- 4) Place a sufficiently large reinforced concrete slab over the shaft which extends beyond the perimeter of anticipated subsidence.

Backfilling

Backfilling a shallow shaft is done by slowly pushing material (usually waste rock from a nearby dump) into the shaft with a crawler tractor. The Anaconda Minerals Company has used this method to successfully backfill a number of shafts in the Butte-Walkerville area which have subsided to the surface.

Advantages of backfilling are:

- 1) No hazard from shaft subsidence exists after filling;
- 2) Unwanted waste material is used which allows waste dump resloping in areas with limited space.

Disadvantages of backfilling are:

- 1) Difficult to completely fill deeper shafts because of bridging;
- 2) Dumps used for borrow may require stabilization and/or revegetation because the existing crusted surface will be disturbed;
- 3) Expensive on deeper shafts, and

- 4) Eliminates access for future mining.

One alternate method of backfilling suggested by the Texas Railroad Commission (pers. comm. March 13, 1984) is to use a conveyor belt to supply fill for the shaft. This would allow uniform filling and possibly could reduce blockage caused by uneven filling which has occurred when waste dump material was bulldozed into deeper shafts.

Concrete Cap or Steel Grate

Two types of caps for major* shafts were considered:

- 1) Reinforced concrete, 12 inches thick, 85 feet by 100 feet and supported by pretressed concrete beams;
- 2) Railroad rails, 120 pounds per 3 feet, on 9-inch centers; in two directions, 66 by 66 feet, decked with 3/16 steel plate.

Of the two types of caps, reinforced concrete is cheaper to construct and would provide better long term service because of resistance to rusting in low pH soils. Advantages of using a concrete cap are:

- 1) Minimum surface disturbance;
- 2) More cost effective than backfilling for deeper shafts, and
- 3) Allows access for future mining.

* The shaft size on major shafts is 9 feet by 25 feet. A pad 85 feet x 100 feet is needed to maintain a seal on the shaft after subsidence occurs (see Appendix A).

Disadvantages of a concrete cap are:

- 1) Expensive for shallow shafts, and
- 2) There is no assurance that slab integrity can be maintained. Caving at depths below 100 feet may occur and cause slumping of the slab.

Concrete and Steel Cone

The third method considered was a steel cone filled with concrete. Typically, a 60 degree cone is used (Van Dyke, 1983) and is constructed of 1/4 inch plate steel. An excavation is made at the surface of the shaft and the cone is inverted and placed with the point of the cone in the open shaft. The cone is then filled with concrete.

Advantages using this method are:

- 1) Provides a good surface seal of the shaft.
- 2) Weight of cone helps to maintain integrity of the shaft collar area.

Disadvantages of the steel cone are:

- 1) The steel cone does not protect against subsurface failure 100 feet or more below the surface unless an unusually large cone (up to 100 feet in diameter) is used or unless the shaft is structurally supported from the surface to a point below the subsurface failure;

- 2) Large excavation is required, and
- 3) Cone cannot be used in shafts with headframes unless headframes are removed.

None of the methods is a complete solution for all problems. Consequently, each shaft must be examined on a case by case basis.

HEALTH HAZARD

Reclamation of nine waste dumps, the Clark Tailings and three baseball parks is recommended to minimize health hazards associated with the respiration and ingestion of mining wastes. The nine waste dumps erode and deposit sediment containing potentially toxic elements in streets. Vehicular traffic pulverizes the sediment into dust which then becomes airborne due to traffic and wind. Two of the baseball fields are barren and are located on or immediately adjacent to waste dumps. Material from a waste dump is eroded by runoff and deposited on the third baseball field. The Clark Tailings are affected by strong winds which erodes the tailings and entrains them in the ambient air. Reclamation options have been developed for these sites and are described below.

Revegetation

Revegetation is a stabilization option at sites where runoff erosion of waste dumps is a significant problem. Revegetation should also be a consideration for the Clark Tailings. If waste dumps are disturbed by shaft backfilling operations, then revegetation may be required.

Embankment resloping will be necessary to effectively revegetate waste dumps. Extensive regrading and runoff control of the Clark Tailings will be necessary to eliminate existing deep erosion if total site revegetation is the objective. Revegetation is an option for the baseball fields but is not necessary. Soil covering only is the recommended option at these sites. Erosion control of adjacent waste dumps must be accomplished to prevent future covering of the fields with waste material.

Interception of Runoff

A less costly solution to runoff erosion control is construction of interception ditches along dump and embankment tops. Erosion ditches or channels could be constructed to intercept and contain the runoff from the mine site plus any tributary area for the design runoff event. The 10-year, 24-hour precipitation event is commonly used for design. Intercepted runoff would be conveyed to one or more convenient locations, discharged down the embankment slope via a closed pipe or a lined channel and then discharged to the community storm drain. If the discharge contained a significant sediment load, a sedimentation pond could be constructed at or near the toe of the embankment and prior to discharge to the storm sewer system.

Rock Mulch

Revegetation of the Clark Tailings would be costly to achieve because of the large area involved (60 acres) and the extensive regrading needed. The application of a thin rock mulch is used extensively by

2. The second part of the document addresses the challenges of data management in a rapidly changing environment. It highlights the need for flexible and scalable solutions that can adapt to new technologies and evolving business requirements. The author argues that organizations must invest in training and development to ensure that their staff are equipped with the skills necessary to manage complex data sets effectively. Additionally, the text stresses the importance of regular audits and reviews to identify potential weaknesses and areas for improvement.

5. The fifth part of the document concludes by summarizing the key points discussed and offering final thoughts on the future of the organization. It reiterates the importance of continuous improvement and the need to stay agile in the face of uncertainty. The author expresses confidence in the organization's ability to overcome challenges and achieve its long-term vision, provided that it remains committed to the principles of transparency, accountability, and collaboration.

the Anaconda Minerals Company to control wind erosion of tailings near Anaconda, Montana and may be successful on the Clark Tailings. The application of a thin rock mulch on flat surfaces of the Clark Tailings would provide effective control of wind erosion at substantially less cost than revegetation.

A thin rock mulch would not control runoff erosion of steep embankments on waste dumps. However, rock mulching would be effective on flat to gently sloping mine sites where wind erosion is an identified problem. If erosion control is necessary at shaft sealing sites, rock mulching would be an economical solution.

1. The first part of the report

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REPORT OF THE JOINT ECONOMIC COMMISSION
ON THE ECONOMIC SITUATION IN THE
UNITED STATES OF AMERICA

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1. The first part of the report is a general introduction to the subject of the study.

2. The second part of the report is a detailed description of the methods used in the study.

3. The third part of the report is a discussion of the results of the study.

4. The fourth part of the report is a conclusion and a list of references.

5. The fifth part of the report is a list of appendices.

6. The sixth part of the report is a list of figures and tables.

7. The seventh part of the report is a list of footnotes.

8. The eighth part of the report is a list of acknowledgments.

9. The ninth part of the report is a list of abbreviations.

10. The tenth part of the report is a list of symbols.

11. The eleventh part of the report is a list of units.

12. The twelfth part of the report is a list of definitions.

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